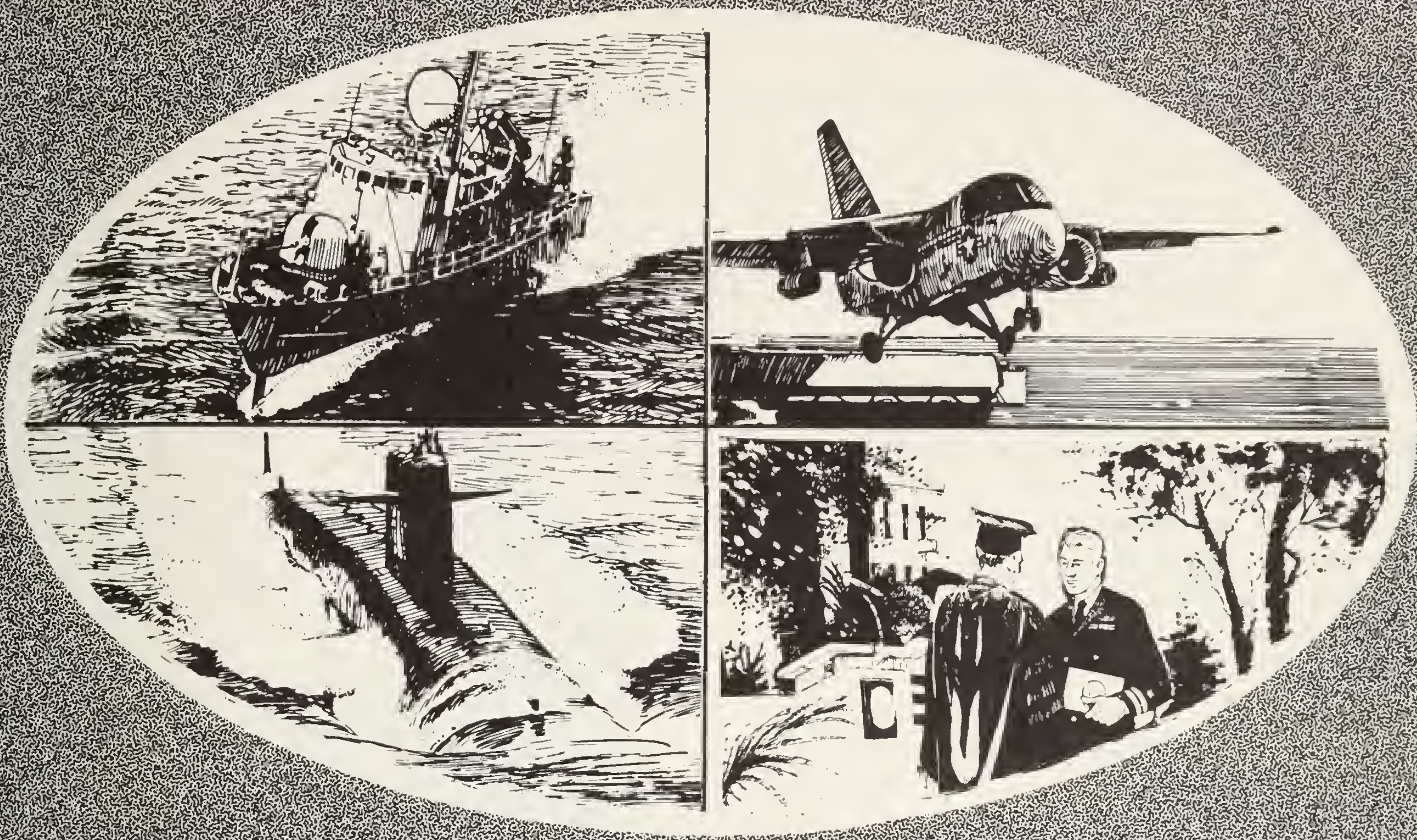
R. Sanders

NAVAL POSTGRADUATE SCHOOL

1981 - 82

MONTEREY
CALIFORNIA

CATALOG



MISSION

To conduct and direct the advanced education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet the needs of the naval service; and in support of the foregoing, to foster and encourage a program of research in order to sustain academic excellence.

NAVAL POSTGRADUATE SCHOOL
Monterey, California 93940

ACADEMIC CALENDAR

Fall Quarter 1981-82

Registration	Thursday, 24 September 1981
Instruction begins	Thursday, 1 October
Columbus Day *(holiday)*	Monday, 12 October
Veterans Day *(holiday)*	Wednesday, 11 November
Thanksgiving *(holiday)*	Thursday, 26 November
End-quarter exams	16-19 December
Graduation exercises	Friday, 18 December

Winter Quarter 1981-82

Registration	Monday, 28 December
Instruction begins	Monday, 4 January 1982
Washington's birthday *(holiday)*	Monday, 15 February
Refresher begins	Tuesday, 16 February
End-quarter exams	22-25 March
Graduation exercises	Friday, 26 March

Spring Quarter 1981-82

Registration	Monday, 22 March
Instruction begins	Monday, 29 March
Memorial Day *(holiday)*	Monday, 31 May
End-quarter exams	14-17 June
Graduation exercises	Friday, 18 June

Summer Quarter 1981-82

Fourth of July *(holiday)*	Monday, 5 July
Registration	Tuesday, 6 July
Instruction begins	Monday, 12 July
Refresher begins	Monday, 23 August
Labor Day *(holiday)*	Monday, 6 September
End-quarter exams	27-30 September
Graduation exercises	Friday, 1 October

Fall Quarter 1982-83

Registration	Monday, 27 September
Instruction begins	Monday, 4 October
Columbus Day *(holiday)*	Monday, 11 October
Veterans Day *(holiday)*	Thursday, 11 November
Thanksgiving *(holiday)*	Thursday, 25 November
End-quarter exams	17-21 December
Graduation exercises	Tuesday, 21 December

1981

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Superintendent
JOHN JOSEPH EKELUND
B.S., U.S. Naval Academy, 1949
M.S. in Systems Analysis
University of Rochester, 1969

Academic Dean
JACK RAYMOND BORSTING
B.A., Oregon State University, 1951;
M.A., University of Oregon, 1952; Ph.D., 1959

BOARD OF ADVISORS

The NPS Board of Advisors is a distinguished group of civilian educators, business, and professional men. The Board visits the campus periodically to examine educational programs, recommend improvements, and discuss plans and problems with the Superintendent. Present members are:

The Honorable Norman D. Dicks, House of Representatives, Washington, DC

Lieutenant General Robert G. Gard, Jr., USA, President, National Defense University

Dr. Kermit O. Hanson, Dean, School and Graduate School of Business Administration, University of Washington

Dr. Gerald J. Lieberman, Vice Provost and Dean of Research, Stanford University

Dr. Nancy R. Mann, School of Medicine, University of California, Los Angeles and Project Manager, Reliability & Statistics, Rockwell International

Dr. Hans Mark, Deputy Administrator for NASA

Dr. Russell R. O'Neill, Dean, School of Engineering and Applied Sciences, University of California, Los Angeles

Dr. David S. Potter, Vice President, Public Affairs Group, General Motors Corporation

Admiral James S. Russell, USN (Ret) (Board Chairman)

Dr. John B. Slaughter, Director, National Science Foundation

Admiral Alfred J. Whittle, Jr., USN, Chief of Naval Material, Navy Department

Mr. Bob Wilson, Member, WITCO Co.

SUPERINTENDENT'S STAFF

DIRECTOR OF PROGRAMS, **Matthew Francis Pasztalaniec,** Captain, U.S. Navy; B.S., U.S. Naval Academy, 1954; M.S., American Univ., 1963.

DIRECTOR OF MILITARY OPERATIONS AND LOGISTICS, **James McAllen Webster,** Captain, U.S. Navy; A.B., Harvard Univ., 1947; B.S., U.S. Naval Academy, 1953; M.S., Naval Postgraduate School, 1964.

DEAN OF EDUCATIONAL DEVELOPMENT and EXECUTIVE DIRECTOR, OFFICE OF CONTINUING EDUCATION, **Walter Max Woods;** B.S., Kansas State Teachers College, 1951; M.S., Univ. of Oregon, 1957; Ph.D., Stanford Univ., 1961.

DEAN OF RESEARCH and DEAN OF SCIENCE AND ENGINEERING, **William Marshall Tolles;** B.A., Univ. of Connecticut, 1958; Ph.D., Univ. of California at Berkeley, 1962.

DEAN OF ACADEMIC PLANNING and DEAN OF INFORMATION AND POLICY SCIENCES, **David Alan Schrady;** B.S., Case Institute of Technology, 1961; M.S., 1963; Ph.D., 1965.

DEAN OF ACADEMIC ADMINISTRATION, **Abraham Sheingold;** B.S., College of the City of New York, 1936; M.S., 1937.

REGISTRAR, **Edith Jean Warriner;** B.A., Occidental College, 1947.

GENERAL INFORMATION

HISTORY

The Naval Postgraduate School is in its 73rd year of operation. The development of a naval institution of higher learning dedicated to the advanced education of commissioned officers began on 9 June 1909 when the Postgraduate Department of the U.S. Naval Academy was established at Annapolis. Ten officers made up the first class, three professors formed the faculty, and marine engineering was the one course of study.

The School closed during World War I, but classes resumed in 1919. In ensuing years, the School grew in size and scope as its educational offerings were more comprehensively directed towards the broad military applications of science and technology. The postgraduate department was renamed the United States Naval Postgraduate School, but still operated as a part of the Naval Academy. In 1927, the General Line Course was established to acquaint junior line officers with modern developments within the Navy and to broaden their professional knowledge of future command at sea.

With the advent of World War II, the School's activities increased substantially. There was a large growth in student enrollment and educational programs were expanded to meet the evolving needs of the Navy. Following the end of the War, plans were initiated to move the School to more suitable facilities and to enhance its academic status.

Between 1945 and 1948, Congress established the School as a separate activity under its own Superintendent, created the office of Academic Dean and granted the Superintendent the authority to award the bachelor's, master's and doctor's degrees. It also approved Monterey as the future home of the School. The General Line School, closed during the war years, was reestablished at Monterey and at Newport, Rhode Island.

After purchasing the former Del Monte Hotel and surrounding acreage, the Navy officially established the School on the West Coast on 22 December 1951. With its enlarged facilities, the School continued to grow in curricular programs and in student enrollment. In 1956, the Navy Management School was formed as a component of the Postgraduate School to provide graduate education in the theory and application of administrative science. In 1958, the General Line School was renamed the General Line and Naval Science School, and a Bachelor of Science curriculum was offered to selected officers who had not completed their undergraduate education. A further need for baccalaureate courses resulted in the inauguration of the Bachelor of Arts curriculum in 1961.

A major internal reorganization of the School was authorized in 1962. The Management, Engineering, and General Line School merged, making the Naval Postgraduate School in effect, a naval university, unified in policies, procedures and objectives.

In 1973, the Naval Postgraduate School, together with the Naval War College and the U.S. Naval Academy, was made a component of the Naval Education and Training Command located at Pensacola, Florida.

Since 1946, the School has awarded 6,168 bachelor's degrees, 9,951 master's degrees, 307 engineer's degrees, and 104 doctorate degrees. At the present time, the total educational emphasis is on graduate-level programs.

Currently, the Naval Postgraduate School occupies a multimillion dollar campus, graduates an average of 800 students a year and offers a range of curricular programs specifically tailored to impart the scientific, engineering, operational and administrative knowledge required to meet the present and projected professional needs of the Department of Defense. Its student body includes officers of all five U.S. services and approximately 25 allied services. Also, since 1975, it has enrolled civilian employees of the U.S. federal government.

ORGANIZATION AND FUNCTIONS

The Superintendent of the Postgraduate School is a rear admiral of the line of the Navy. His principal assistants are a Provost/Academic Dean who is the senior member of the civilian faculty; and two captains of the line — a Director of Programs, and a Director of Military Operations and Logistics.

The academic programs and direct supporting functions are administered and operated through a unique organization composed by Curricular Offices and Academic Departments. The former are staffed by naval officers and civilian faculty members whose primary functions are threefold: (1) academic counseling and military supervision of officer students; (2) curriculum development and management to insure attainment of professional and academic objectives; and (3) liaison with curricular sponsor representatives. Officer students in each curricula group pursue similar or closely related curricula.

Officer students are grouped into the following curricular program areas:

Administrative Science
Aeronautical Engineering
Air-Ocean Sciences
Command, Control and
  Communications (C3)
Computer Technology
Electronics and Communications
National Security Affairs/
  Intelligence
Naval Engineering
Operations Research/Systems Analysis
Weapons Engineering/ASW

The teaching functions of classroom and laboratory instructions and thesis supervision are accomplished by a faculty which is organized into eleven academic departments and three interdisciplinary groups:

Administrative Sciences
Aeronautics
ASW Group
Command, Control and
  Communications (C3) Group
Computer Science
Electrical Engineering
Electronic Warfare Group
Mathematics
Mechanical Engineering
Meteorology
National Security Affairs
Oceanography
Operations Research
Physics and Chemistry

Over five-sixths of the teaching staff are civilians of varying professional rank and the remainder are military officers.

The Academic Program organization is supervised by the Director of Programs, the Dean of Information and Policy Sciences, and the Dean of Science and Engineering who collaborate to share jointly the responsibilities for planning, conduct and administration of the several education programs.

The close tie between elements of this dual organization is further typified by the role of the Academic Associates. These are individual civilian faculty members appointed by the Academic Dean to work closely with the Curricular Officers in the development and continuing monitoring of curricula — the Navy's needs constituting the responsibility of the Curricular Officer, and academic soundness the responsibility of the Academic Associate.

Logistic service support is rendered by conventional departments such as Supply and Public Works grouped organizationally under a Director of Military Operations and Logistics. Certain other officers such as the Comptroller and Civilian Personnel Officer are directly responsible to the Superintendent in a slightly modified but typical naval staff organization.

FACILITIES

The Naval Postgraduate School is located within the City of Monterey, and only a mile east of the downtown business area and the city's Fisherman's Wharf. The site of the School is the former Del Monte Hotel of pre-World War II days. The beautifully landscaped campus contains most of the academic and administration buildings within the main grounds. There is an adjacent beach area for research and a nearby laboratory and recreation area. The total campus covers approximately 600 acres.

The Superintendent and central administrative officers, along with other service functions, are located in Herrmann Hall, the most prominent building on the campus because of its Spanish architecture.

Most of the academic classrooms, laboratories and offices are located in Spanagel, Bullard, Halligan, Root and Ingersoll Halls. The Dudley Knox Library is adjacent to Ingersoll Hall. Adjacent to Spanagel Hall is King Hall, a large lecture hall used to seat the student body, faculty, and staff when occasions require.

STUDENT AND DEPENDENT INFORMATION

Monterey Peninsula and the cities of Monterey, Carmel, Pacific Grove, and Seaside, all within 5 miles of the School, provide community support for the students of the Postgraduate School.

LaMesa Village, located 3 miles from the School, consists of former Wherry Housing, Capehart Housing and Townhouses. There are a total of 877 units of public quarters for officer students. An elementary school is located within the housing area. Limited housing for single students is available in the BOQ located on the main campus in Herrmann Hall.

Students services include a campus branch of Bank of America, Navy-Federal Credit Union, U.S. Post Office, Student Mail Center, Navy Exchange, and a child care center. A large commissary is located at Fort Ord and is available to Navy personnel.

Medical facilities include a Dispensary, supported by the U.S. Army Hospital at Fort Ord (7 miles away), and the U.S. Navy Hospital at Oakland (120 miles away). A Dental Clinic is located in Herrmann Hall.

The center of campus social activity is the Commissioned Officers and Faculty Club, located in the old hotel building. There are many beautifully appointed rooms, just as they were at the turn of the century, including a ballroom and Open Mess. Two beautiful chapels are located on the main campus.

Student wives and wives of allied officers are active in the officer Students Wives Club, the International Wives Club, and a Little Theater group which puts on three productions a year.

Recreational facilities include a swimming pool, an 18-hole golf course, putting green, tennis courts, ping pong and badminton courts, basketball and volley ball courts, a softball diamond, picnic grounds, bowling lanes, driving range, archery range, and gymnasium. Other organized recreational activities are provided by the Ladies Golf Association, Mens Golf Association, Soccer Club, Rugby Club, Lacrosse Club, Karate Club, Tennis Club, and basketball and softball teams. The School also has a very active Military Amateur Radio Station and a Navy Flying Club.

Personnel assigned to the Postgraduate School have an active Sailing Association open to sponsors and their dependents as well as members of the faculty. Sailing conditions are among the finest on the West Coast with excellent weather prevailing from February through November. The School's recreation department schedules the 2 Shields Class Racing Sloops, 2 Santana-22s, 2 Columbia 22s, and 1 forty-foot launch on a first-come first-served basis. Classes for beginners and advanced sailing enthusiasts are conducted quarterly, following each student input. The School works closely with civilian yacht clubs to coordinate many sailing events throughout the year and, in addition, hosts the annual Navy West Coast Match racing championships.

TEXTBOOKS

The Naval Postgraduate School operates a bookstore under the Navy Exchange system. It stocks all required supplies. Students can purchase their books either from the school or local bookstores, or from other students.

ADMISSIONS PROCEDURES

U.S. NAVAL OFFICERS

U.S. Navy officers interested in admission to one of the curricula offered at the Postgraduate School are referred to **OPNAVNOTE 1520, Subj: Postgraduate Education Program,** which is published annually by the Chief of Naval Operations. This directive outlines the various educational programs available and indicates the method of submitting requests for consideration for each program.

A selection board is convened annually by the Commander, Naval Military Personnel Command to select officers, based upon professional performance, academic background, and ability, within quotas which reflect the Navy's requirements in the various fields of study available. Officers will be notified of selection by official correspondence at the earliest feasible date after the meeting of the selection board.

An officer's chances for selection will be enhanced if he has completed recommended preparatory courses for the graduate-education program of his choice. Appropriate courses for individual self-study are available from the Naval Postgraduate School Continuing Education Program, described in a following section of this catalog.

OTHER U.S. MILITARY OFFICERS

Officers on duty with other branches of service are eligible to attend the Postgraduate School. They should apply in accordance with the directives promulgated by the Department of the Army, Department of the Air Force, Commandant U.S. Marine Corps, or the Commandant U.S. Coast Guard, as appropriate.

ALLIED COUNTRY MILITARY OFFICERS

Military officers from Allied countries may be admitted to most curricula. Their admission is subject to availability of quotas assigned to each country. The procedures for application are contained in **OPNAV INSTRUCTION 4950.1E.** Correspondence must be processed through normal channels; requests from individual officers should not be sent directly to the Naval Postgraduate School. In addition to fluency in English, candidates must satisfy the academic standards for each curriculum as described in this catalog.

CIVILIAN EMPLOYEES OF U.S. GOVERNMENT

Civilian employees of the United States federal government may be admitted for study upon request and sponsorship by a federal activity. They do not need to pursue the curricula designed for officer students as described in this catalog but instead will determine the combination and sequence of courses that will best meet their educational needs.

Requests for admission should be in letter form, indicating the academic area of interest and degree intentions, and enclosing official transcripts of all previous college work. GRE and/or

GMAT test scores are not required but will be considered when included in the submission.

Requests for admission or questions regarding admission procedures should be directed to the Dean of Academic Administration, Code 014, Naval Postgraduate School, Monterey, CA 93940; or telephone (408) 646-2391 or Autovon 878-2391.

TRANSFER OF CREDITS

Upon entry to the Naval Postgraduate School, each student's academic record will be evaluated for possible transfer of credit or for exemption from portions of the curricular program by validation of course work previously completed. Students may also utilize knowledge gained through self-study, experience or service-related education to seek validation or credit for curricular courses by taking a departmental examination.

Certain graduate-level courses previously completed may be accepted for transfer credit. These include graduate-level courses taken after completion of the baccalaureate degree and those taken in the last term before award of the baccalaureate and certified to be in excess of degree requirements.

As a consequence of its policy on transfer of credit, the School requires only 12 quarter hours in residency for the master's degree. Questions on transfer credit may be directed to the Dean of Academic Administration by letter or autovon 878-2391.

DEGREES, ACCREDITATIONS, AND ACADEMIC STANDARDS

The Superintendent is authorized to confer Bachelor's, Master's, Engineer's or Doctor's degrees in engineering or related fields upon qualified graduates of the School. The authority is subject to such regulations as the Secretary of the Navy may prescribe, contingent upon due accreditation from time to time by the appropriate professional authority of the applicable curricula. Recipients of such degrees must be found qualified by the Academic Council in accordance with prescribed academic standards.

The Naval Postgraduate School is accredited by the Accrediting Commission for Senior Colleges and Universities of the Western Association of Schools and Colleges. Specific engineering curricula have been accredited by the Accrediting Board for Engineering and Technology (ABET).

The Postgraduate School operates under a quarter system, with each term of instruction lasting 12 weeks. The last week of each quarter is set aside for examinations. In addition, there are two 2-week recesses during the academic year, one over Christmas and one during June-July.

Students' academic performance is evaluated in terms of quality points assigned to the letter grade achieved in a course. Based on the level of achievement associated with each letter grade, the corresponding quality point values range from a maximum of 4 to a minimum of 0 as follows:

Grade	*Point Value*
A	4
A-	3.7
B+	3.3
B	3
B-	2.7
C+	2.3
C	2
C-	1.7
D+	1.3
D	1
X	0
*WX	0

**Withdrew Failing*

Letter designations for which no quality points are assigned include the following:

I	Incomplete
W	Withdrew Passing
N	Ungraded
P	Pass
F	Fail

Courses may be designated for P and F grading when approved by the Academic Department and the Academic Council. Hours earned by the grade of P shall be counted toward fulfilling course hours specified by the degree requirements.

A grade of Incomplete (I), if not removed within twelve weeks following the end of the term for which it was received, will be replaced by the grade "X". Exceptions must be individually approved by the Academic Council.

When the quarter-hour credit of a course is multiplied by the point value of the student's grade, a quality point value for the student's work in the course is obtained. The sum of the quality points for all courses divided by the sum of the quarter-hour credit of these courses gives a weighted numerical evaluation of the student's performance, termed the Quality Point Rating (QPR). A student achieving a QPR of 3.0 has maintained a B average in all courses undertaken with a proper weight assigned for course hours.

Officer students have no major duties beyond applying themselves diligently to their studies. It is expected that students will maintain a high level of scholarship and develop attributes which are associated with a scholar seeking knowledge and understanding. Program schedules are such that the student should anticipate spending several hours in evening study each weekday to supplement time available for study between classes.

The courses listed in this catalog are assigned course numbers in accordance with their levels of academic credit as follows:

0001-0999	No credit
1000-1999	Lower division credit
2000-2999	Upper division credit
3000-3999	Upper division or graduate credit
4000-4999	Graduate credit

The two numbers in parenthesis (separated by a hyphen) following the course title indicate the hours of instruction per week in classroom and laboratory respectively. Laboratory hours are assigned half the value shown in calculating quarter hours for the credit value of the course. Thus a (3-2) course (having three hours recitation and two hours laboratory) will be assigned credit value of 4 quarter hours.

DEGREE REQUIREMENTS

Certificates of Completion

Certificates of Completion are issued to students who complete programs but do not qualify for a degree. To establish eligibility for a Certificate of Completion, a student must normally maintain an overall QPR of 2.0 or better.

Requirements for the Master of Arts and Master of Science Degrees

1. The Master's Degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Master's Degree are as follows:
   a. 32 quarter hours of graduate level credits of which at least 12 quarter hours must be earned on campus.
   b. A thesis or its equivalent is required. If the thesis be waived, at least 8 quarter hours of approved courses 4000-4999 shall be substituted for it.
   c. Departmental requirements for the degree in a specified subject.

3. Admission to a program leading to the Master's degree requires:
   a. A baccalaureate degree or the equivalent.
   b. Appropriate undergraduate preparation for the curriculum to be

pursued. If a student enters the Postgraduate School with inadequate undergraduate preparation, he will be required to complete the undergraduate prerequisites in addition to the degree requirements.

c. A demonstrated academic potential for completing the curriculum.

4. In order to qualify for a Master's degree, a student first must be admitted to candidacy for the degree. The student may be admitted to candidacy subsequent to completion of 50% of a curriculum and prior to the last quarter under the following conditions:

a. The Total QPR equals or exceeds 3.00.

b. The Total QPR is between 2.50 2.99 and approval for admission has been obtained in accordance with procedures established by the Academic Council.

Students having a Total QPR below 2.50 will be not admitted to candidacy for the Master's degree.

5. To be eligible for the Master's degree, the student must attain a minimum average quality point rating of 3.00 in all the 4000 and 3000 level courses in his curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

Requirements for the Degree: Engineer

1. The Engineer degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree.

2. Minimum Postgraduate School requirements for the degree of Engineer are as follows:

a. 72 quarter hours of graduate level courses including at least 30 hours in courses 4000-4999.

b. An acceptable thesis.

c. One academic year in residence.

d. Departmental requirements for the degree in a specified Engineering field.

e. A quality point rating of at least 3.00 in all graduate courses in the curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

Requirements for the Doctor's Degree

Any program leading to the Doctor of Philosophy or Doctor of Engineering shall require the equivalent of at least three academic years of study beyond the baccalaureate level, with at least one academic year being spent at the School. A requirements for admission is a Bachelor's degree that includes the prerequisites for full graduate status in the department of his major study.

A general outline of a candidate's progress through the program is as follows:

a. Application to the appropriate department chairman for admission and acceptance.

b. Appointment of the student's Doctoral Committee, which bears responsibility for the study program and guidance of the research program.

c. Inclusion of one or more minors in the study program.

d. For the Doctor of Philosophy, a foreign language requirement may be included at the discretion of the major department; For the Doctor of Engineering, demonstrated proficiency in computer programming is required.

e. When study program is essentially complete, administration of the Qualifying Examination, including both oral and written parts.

f. Admission to candidacy and start of work on Doctoral Dissertation on a subject approved by the Doctoral Committee.

g. Upon completion of dissertation and acceptance by Doctoral Committee, administration of final oral examination.

h. Upon unanimous recommendation of Doctoral Committee, Academic Council makes final decision on recommendation for award of the degree.

ACADEMIC HONORS

PROFESSIONAL SOCIETIES. Students have the opportunity to attend many professional meetings held at the Naval Postgraduate School. Several local chapters provide for student membership. These include Eta Kappa Nu, Sigma Xi, Tau Beta Pi, as well as ACM (Association for Computing Machinery), AIAA (American Institute of Aeronautics and Astronautics), AMS (American Meteorological Society, ASME (American Society of Mechanical Engineers), ASNE (American Society of Naval Engineers), IEEE (Institute of Electrical and Electronics Engineers, Inc.), ORSA (Operations Research Society of America), the Marine Technology Society, and AFCEA (Armed Forces Communications and Electronics Association).

DEAN'S LIST. Students who distinguish themselves academically are recognized at the end of each quarter by being placed on the Dean's List. This recognition is awarded to students who earn a Quality Point Rating of 3.65, or higher, while carrying a minimum academic load of 12 quarter hours for which quality points have been assigned.

GRADUATION WITH HONORS. The award of the Master of Science degree may be made "With Distinction" when a student completes the degree requirements with a minimum of 32-quarter hours earned in residence and is in the upper 10% of the graduating class.

SIGMA XI. The Naval Postgraduate School has a Chapter of the Society of the Sigma XI, an honorary society founded to recognize excellence in the scientific and engineering disciplines. Students who have demonstrated marked promise in their research work are considered for membership each year. The number elected is limited only by the quality of the research work done for a graduate degree.

MEWBORN STUDENT RESEARCH AWARD. This award affords recognition for exceptional research talent. It is awarded annually to a student in a program of graduate scientific or engineering studies, leading to an advanced degree, whose thesis exhibits sound scholarship and outstanding research ability.

CAPTAIN J.C. WOELFEL AWARD. This award is given annually to the United States Naval Officer student receiving an advanced degree in the Naval Engineering Programs who has demonstrated the most outstanding academic record, and at the same time possesses those attributes best exemplifying a Naval Officer.

W. RANDOLPH CHURCH AWARD. This award is given annually to a student on the basis of his performance in mathematics courses. The criteria for selection will include evidence of initiative, scholarly attitude and mathematical maturity. The student need not be a mathematics major, nor must he be a graduate at the time of presentation.

NAVAL ELECTRONIC SYSTEMS COMMAND AWARD IN ELECTRONICS ENGINEERING. This award will be given semiannually to a Master of Science candidate in the Advanced Electronics Engineering Program who has a most outstanding academic record and whose qualities indicate an outstanding military officer.

NAVY LEAGUE OF MONTEREY AWARD FOR HIGHEST ACADEMIC ACHIEVEMENT. This award is presented quarterly to the graduating U.S. Navy, Marine Corps or Coast Guard officer who has maintained the highest academic grade average as a student at the Naval Postgraduate School.

ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION AWARDS. This award is presented to a student who has achieved academic excellence and demonstrated professional qualities in fields of interest to the AFCEA organization. The selection will be made, on a quarterly rotational basis, from among graduates of the Electronics/Communications, C3, Computer Technology, and Naval Intelligence programs, respectively.

NAVAL SEA SYSTEMS COMMAND AWARD IN NAVAL ENGINEERING. This award affords recognition to a graduate of any curriculum leading to a Master of Science degree in Mechanical or Electrical Engineering who has demonstrated academic excellence through attainment of a high Quality Point Rating in addition to an outstanding thesis, and who has exhibited leadership potential in the engineering area.

CHIEF OF NAVAL OPERATIONS AWARD FOR EXCELLENCE IN OPERATIONS RESEARCH. This award is presented semiannually to an outstanding United States Navy or Marine Corps graduate of the Operations Research/Systems Analysis curriculum. The award is made on the basis of academic record, performance during the student's experience tour, and faculty recommendation.

ADMIRAL WILLIAM ADGER MOFFETT AWARD. This award is presented annually to an outstanding graduate of the Aeronautical Engineering curriculum. The award is made on the basis of the student's academic excellence, including thesis, and his career potential.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS AWARD. This award is presented semiannually to the graduate in an advanced communications degree program achieving an outstanding academic record and exhibiting those qualities indicative of an outstanding military officer.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS CERTIFICATE. This certificate is presented quarterly to the Master of Science graduate who shows the greatest academic improvement in a communications curriculum.

CHIEF OF NAVAL OPERATIONS ASW AWARD. This award is given annually to the most outstanding student graduating from the antisubmarine warfare curriculum.

DIRECTOR OF NAVAL INTELLIGENCE GRADUATION AWARD. This award is presented annually to recognize the most outstanding student in the Naval Intelligence curriculum.

NAVAL SEA SYSTEMS COMMAND AWARD IN WEAPONS ENGINEERING EXCELLENCE. This award is given annually to the most outstanding officer graduate of the Weapons Systems Engineering curricula.

NAVAL UNDERWATER SYSTEMS AWARD IN SUBMARINE WARFARE SYSTEMS. This award is given annually to the officer student graduate who has demonstrated the greatest contribution in the field of submarine warfare systems.

JOINT CHIEFS OF STAFF COMMAND, CONTROL AND COMMUNICATIONS AWARD FOR ACADEMIC ACHIEVEMENT. This award is presented annually to the outstanding graduate of the C3 curriculum. It is made on the basis of academic record, thesis research and faculty recommendations.

MILITARY OPERATIONS RESEARCH SOCIETY GRADUATE RESEARCH AWARD. This award is given semiannually to a student on the basis of outstanding achievement in graduate research directed toward improving military force utilization.

NAVAL ELECTRONIC SYSTEMS COMMAND ELECTRONIC WARFARE TECHNOLOGY AWARD. This award is presented annually to a Master of Science candidate in the Electronic Warfare Systems Technology Program. The award is made on the basis of academic excellence, including the quality and relevance of the thesis, and leadership qualities.

OCEANOGRAPHER OF THE NAVY AIR-OCEAN SCIENCE AWARD. This award is presented annually to a U.S. Navy officer graduate of the Air-Ocean Science program who has demonstrated outstanding academic performance and has exhibited those qualities indicative of an outstanding military officer.

UNITED STATES NAVAL INSTITUTE AWARD. This award is presented quarterly to that recipient of a Master's Degree in National Security Affairs whose achievement has significantly advanced professional, literary or scientific knowledge in the naval or maritime services.

U.S. ARMY TRAINING & DOCTRINE COMMAND AWARD FOR ACADEMIC EXCELLENCE IN OPERATIONS RESEARCH. This award is given semiannually to the outstanding U.S. Army student in the Operations Analysis Program.

SUPERINTENDENT'S GUEST LECTURE PROGRAM

Throughout the Academic Year lectures will be presented on Tuesday afternoons in King Hall for students, faculty and staff. Eminently qualified civilian and military authorities from a wide range of fields and accomplishments will speak on subjects of current and historical interest in international government, sociological, and military affairs. Occasionally speakers are presented in the evening with wives also invited to attend. The primary purpose of this series is to inform as well as to stimulate and challenge the thinking of the officer students in areas outside of their immediate academic pursuits.

NAVAL POSTGRADUATE SCHOOL FOUNDATION

The Foundation is a nonprofit corporation whose purposes are:

> "to solicit, receive, and administer contributions and make donations and dispense charitable contributions ... and otherwise aid, encourage and support the traditions of the Naval Postgraduate School ...."

The corporation was formed in December 1970, and has since served as a vehicle by which large and small tax-exempt gifts have been easily and quickly given to the School. These gifts are all applied to those needs or purposes which would otherwise — in these days of severe fiscal restraint — be poorly-or not-at-all funded.

The Rear Admiral John Jay Schieffelin Award for Excellence in Teaching was endowed through the Foundation. A black granite sculpture, FLIGHT, located in the Dudley Knox Library, was donated to help publicly honor the recipients of this prestigious and valuable award.

The Foundation, in cooperation with the Office of Naval Research, administers the Carl E. Menneken Fellowship for Scientific Research. This annual award of $1,000 has the dual objectives of furthering the progress of engineering and science in areas of importance to the Navy and to provide aid to a worthy doctoral student involved in a research program expected to be of benefit to the Navy. The award honors the memory of Carl E. Menneken who devoted his career to the Navy as Distinguished Professor of Electronics and Dean of Research Administration at the Postgraduate School.

The School's Sailing Association owes the majority of its present assets to donations made to the Foundation. Small donations have also been received from some "friends of the Library" who wished to create a small but meaningful and useful memorial.

The Directors of the Corporation are civilians, except for the Superintendent who serves to assure that only gifts appropriate to the School are accepted.

Individuals wishing to participate in the work of the Foundation may write to the Secretary, Naval Postgraduate School, Monterey, California 93940.

CIVILIAN EDUCATION PROGRAM

All civilian employees of the United States government are eligible to enroll in the courses, curricula, and degree programs of the School. Enrollment is subject to the approval of the individual's employing agency for his participation. An individual may enroll in one of the regular curricula designed for officers, in a specially designed degree program, in a selection of courses making up a non-degree program, or in a Continuing Education course.

Regular Curricula. The School's programs for officers are designed to meet the requirements of the services for specific education. Civilian students may enter any curriculum at the point at which they are qualified and complete the curriculum along with the officer students. The available curricula are described later in the catalog.

Degree Programs. For a civilian student, an individual program can be tailored to meet his educational needs while leading to the award of a graduate degree. The program can be designed to meet the degree requirements in a minimal time. A preparatory phase (off-campus), designed to minimize the residency requirement, is developed in consultation with a School advisor and may include courses at a local university, self-study courses from the School, and other appropriate activities. The residency phase, usually one year or less in length, entails completing the course work, passing any required qualifying examinations, and starting a thesis project. The third phase (on- or off-campus) involves completion of the thesis project.

Degree programs are described in the departmental descriptions. Those available include Masters degrees in the areas of Naval Intelligence, National Security Affairs, Operations Research, Financial Management, Personnel Management, Systems Acquisition Management, Telecommunications Systems, Command Control and Communications (C3), Computer Systems Management, Material Management, Human Resources Management, Mathematics, Physics, Meteorology, Oceanography, Aeronautical Engineering, Mechanical Engineering, Electrical Engineering, Systems Technology, Applied Science, Anti-Submarine Warfare, Electronic Warfare, Avionics, Computer Science and Engineering Science.

Engineer degree programs are available in Aeronautical, Electrical and Mechanical Engineering.

The Doctor of Philosophy is given in Physics, Oceanography, Meteorology, Operations Research, Aeronautical Engineering, Electrical Engineering, Mechanical Engineering, and Engineering Acoustics. The Doctor of Engineering is given in Aeronautical, Electrical and Mechanical Engineering and in Engineering Acoustics.

Non-Degree Programs. Prospective civilian students may desire to pursue a program of professional advancement without a degree objective. Any of the School's regular courses are available for such efforts. For groups of employees from an agency, special course offerings can be developed to meet particular requirements, provided the demand is in an area of expertise of the School.

Continuing Education. The opportunities available include short course offerings both on and off campus, as well as self-instructional courses for credit to be taken individually. The Continuing Education Program is described in detail in the following section.

There are no formal requirements for enrollment in the Continuing Education Program or for a non-degree program. For admission to a program leading to a graduate degree, the minimum qualification is an accredited baccalaureate degree with appropriate preparation for the proposed degree program. The School will require submission of official transcripts covering all college work completed to date. In some cases, submission of Graduate Record Examination aptitude test scores may be requested.

The point of contact for information pertaining to on campus programs and admission to degree programs is the Dean of Academic Administration, Code 014, telephone (408) 646-2391 or autovon 878-2391. For information concerning continuing education, the contact point is the Executive Director of Continuing Education, Code 500, telephone (408) 646-2558 or autovon 878-2558.

CONTINUING EDUCATION PROGRAM

The Naval Postgraduate School Continuing Education Program was established in June 1974 as a means of providing extended educational services that will more comprehensively fulfill the school's assigned mission. These extended services include the offerings of self-study credit courses off campus; the delivery, both on and off campus, of professionally relevant short courses; and expanded educational counseling. The self-study credit course offerings are listed in the Catalog of Self-Study Courses which is distributed annually to nearly all ships and stations in the Navy and to selected offices of other DoD establishments. This program is administered by the Continuing Education Office.

Selected graduate preparatory courses are delivered off campus in a self-study self-paced mode for the same academic credit as received when taken on campus. These self-study courses are delivered to officers at their current duty stations for completion during off-duty hours or work/study periods. They have been selected from courses normally taken in the initial phase of curricular programs at the Naval Postgraduate School. Their successful completion will enhance selection for postgraduate education, enhance performance in early phases of graduate education programs, and reduce course requirements in curricular programs at the Naval Postgraduate School. The delivery of a self-study credit course normally requires the local participation of a qualified tutor (e.g., a civilian or officer with requisite graduate education). Self-study courses taken for review do not require a tutor.

Application for enrollment in a self-study course may be made at any time. Applicants should use the appropriate form contained in the last section of the self-study catalog. Self-study courses are also available to civilian employees of the federal government.

Commands with available funds may arrange for delivery on site of short courses to meet specific needs on a direct reimbursable basis to the Naval Postgraduate School. Delivery costs may be obtained from the Continuing Education Office.

More information on short courses and self-study courses is available from the Continuing Education Office, Code 500, Naval Postgraduate School, Monterey, CA 93940, or telephone (408) 646-2558 or autovon 878-2558.

ACADEMIC COUNSELING SERVICE

The Naval Postgraduate School has established an academic counseling service to assist officers in developing individual educational plans. Officers who have chosen specific curricula, or who have been selected or detailed for graduate education in curricular programs at the Naval Postgraduate School should direct inquiries to the appropriate curricular office. Specifically, requests for names of courses that can be taken in a self-study mode to prepare for specific curricula at the Naval Postgraduate School should be directed to the appropriate curricular officer.

The Naval Postgraduate School has been assigned the responsibility to prepare an abstract of each selected or newly commissioned Naval officer's academic background, leading to the development of a three-digit Academic Profile Code (APC), summarizing his pertinent academic qualifications. Officers seeking information about their APC or academic qualifications, should contact the Dean of Academic Administration, Code 014, Naval Postgraduate School, Monterey, CA 93940, or telephone (408) 646-2392 or autovon 878-2392. Officers completing courses to upgrade their APC should forward transcripts (not grade reports) to Code 0145 at the Naval Postgraduate School.

Officers seeking general information about sub-specialty codes, selection for graduate education, and preliminary information about graduate education commensurate with career fields should contact the Office of Continuing Education, Code 500, Naval Postgraduate School, or telephone (408) 646-2984 or autovon 878-2984.

Inquiries pertaining to curricula not offered at the Naval Postgraduate School should be directed to Manager, Civilian Institution Program, Naval Postgraduate School, Monterey, CA 93940, or telephone (408) 646-2319 or autovon 878-2319.

Herrmann Hall — Administration Building, Naval Postgraduate School

COMPUTER FACILITIES

W.R. CHURCH COMPUTER CENTER

Operator's console area of IBM 3030 computer

STAFF

Douglas George Williams, Professor and Director (1961)*; M.A. (Honours), Univ. of Edinburgh, 1954.

Roger Rene Hilleary, Manager, User Services (1962); B.A., Pomona College, 1953; M.S., Naval Postgraduate School, 1970.

David Fredric Norman, Manager, Systems Support Group (1969).

Clarence William Kellogg, Manager, Operations (1968); A.S., Monterey Peninsula College, 1969.

Alyce Louisa Austin, Systems Support Group (1977); B.S., Naval Postgraduate School, 1981.

Joanne Rose Bogart, User Services Group (1979); B.S., Stanford Univ., 1970; M.A., Univ. of Illinois, 1971; M.S., Cornell Univ., 1974; Ph.D., 1976.

Kristina Louise Butler, Systems Support Group (1970).

Mary Elizabeth Curry, Administrative Staff (1972); B.A. (High Honors), Univ. of Maryland, 1970.

Hans Welter Doelman, Systems Support Group (1967); B.S., Univ. of California at Berkeley, 1956.

Richard Eugene Donat, Systems Support Group (1968); B.S., California State Polytechnic Univ., 1967.

Jane Lee Foust, User Services Group (1978); B.A., Colorado College, 1966.

Neil Edward Harvey, User Services Group (1980); B.S., The Citadel, 1962.

Dennis Ronald Mar, User Services Group (1980); B.A., Univ. of California at Berkeley, 1968; M.S., Iowa State Univ., 1970.

Caroline Jennette Miller, User Registration and Accounting (1975); B.Ed., Univ. of Hawaii, 1966; M.S., Univ. of Rhode Island, 1972.

Frances Lee Wheeler, User Services Group (1979).

**The year of joining the Postgraduate School is indicated in parentheses.*

The Naval Postgraduate School was one of the first educational institutions to use digital computers in its instructional and research programs. The first machine, an NCR 102A, was installed in 1954 and operated by the Department of Mathematics. A central Computer Facility was created in 1960 as an organizational unit separate from the academic departments. In December, 1969, the Facility was renamed the W. R. Church Computer Center in memory of Professor Church, Chairman of the Department of Mathematics (1947-66), who recognized very early the value of computers in education and was instrumental in obtaining the first computers at the School.

The many services of the Center are available to all faculty, staff, and students of the School for use in instruction, research, or administrative activities.

These services are based on an IBM 3033 Attached Processor system which was installed in January 1981. The present hardware configuration includes an IBM 3033 central processor and IBM 3042 attached processor, 16 megabytes of processor storage, 2 drums with 12 megabytes each as paging devices, 24 IBM 3350-1 disk drives (317 Mbytes each), 6 IBM 3270-8 tape drives (6250 bpi), a mass storage system containing cartridges of 50 Mbytes each, and 120 IBM 3278-2 CRT displays.

The principal mode of access is via the public IBM 3278 terminals located in clusters in the academic buildings and attached by coaxial cable to the computer in Ingersoll Hall. In addition, there are 12 IBM 3277 APL/Graphics displays available for public use. The system supports two major operating systems, MVS (Multiple Virtual Systems) running batch-processing under VM/370 (Virtual Machine), and CMS (Conversational Monitor System) providing interactive support. The extensive programming facilities include Fortran IV H Extended, WATFIV, VS COBOL, WATBOL, PL/1 Optimizer, BASIC, VS APL, and Pascal. Most languages are available in both interactive and batch-processing modes.

The School has a heavy commitment to computers consistent with their present and future role in military operations. All of the academic curricula have been affected by the presence of computers on campus. The percentage of active student and faculty participation in the computer field is at a level probably unequalled at any other educational institution. All graduate students take at least one course in computer science. They are introduced to the computer early in their curricula at the Naval Postgraduate School and encouraged to use it in subsequent course work and research.

The Computer Center supports a wide variety of specialist courses in computer science offered by the Departments of Computer Science, Electrical Engineering, Mathematics, Operations Research and Administrative Sciences.

The Center has a staff of 24 people, 12 of whom are involved in programming. The professional staff provides a consulting service in application programming, systems programming and problem formulation to students and faculty members. They participate in an active research and development program directed primarily towards improving the present operational environment or introducing new hardware and software facilities to users. Current projects include work on systems measurement, improvement of operating systems, graphical data processing, time-sharing facilities, and numerical analysis.

Since 1975 the Center has provided data processing support to the tenant activity, Defense Manpower Data Center (DMDC).

COMPUTER LABORATORIES

STAFF

George Anthony Rahe, Director and Professor of Computer Science (1965)*; B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

Phillip Jeffrey Balma (1980); B.S., Univ. of California at Riverside, 1970; M.S., Univ. of Oregon, 1979.

Walter Lewis Landaker (1960); B.A., San Jose State, 1956.

Robert Michael McDonnell (1978); U.S.A.F. Technical School, 1967.

Alan Dain Samples (1980); B.S., Purdue Univ., 1974; M.S., 1976.

William Arthur Thomas (1969); B.S., Univ. of California at Los Angeles, 1957.

Michael Arthur Williams (1978); B.E.T., DeVry Institute of Technology, 1973.

Albert Wong (1970); B.S., West Coast Univ., 1957.

**The year of joining the Postgraduate School is indicated in parentheses.*

The Naval Postgraduate School's computer laboratory, established in 1960 with the acquisition of a CDC 160, was one of the nation's first computer graphics research facilities. In 1967, the laboratory's capabilities were significantly extended through the acquisition of an SDS 9300 general purpose digital computer, a COMCOR Ci-5000 hybrid-analog computer and two Adage AGT-10 graphics terminals. The resulting multi-processor system, located in the Real-Time Systems Laboratory, has provided real-time computing capability for simulations of various military systems, for the development of acoustic-signal processing techniques and for a host of other research and instructional activities.

Today, in addition to the Real-Time Systems Laboratory, other laboratories that have been developed include the Signal Processing and Display Laboratory, the Image Processing Laboratory and the Command, Control and Communications Laboratory. These laboratories are available to all faculty, staff, and students who require their specialized facilities for teaching, classwork, or research.

The hardware complement of the Signal Processing and Display Laboratory includes two DEC PDP-11/50's and a PDP-11/34. There are also a CSPI-125 fixed-point array processor and a CSPI MAP-300 floating-point array processor. Analog signal conditioning equipment consists of a Honeywell Ninety Six analog/FM magnetic tape system, amplifiers, filters and an analog-to-digital convertor. Also, there is a 3-ported 300-megabyte disk system, 3 magnetic tape drives, a line printer, a card reader, a paper tape punch/reader, a 200 point/inch electrostatic printer/plotter, and over 30 terminal ports allowing for remote access via hardcopy or video terminals.

Graphics systems in the laboratory are a cross-section of contemporary graphics technology. Included are two Vector General 3D31 systems, a Hughes Conographic-12, a Tektronics-4014 and a Tektronics-4051 storage tube systems, a Ramtek GX-100A color raster display system and two plasma displays.

The Image Processing Laboratory's hardware consists of a EYECOM monochromatic picture digitizer and display, a Ramtek 9400 high resolution color raster display system and a Vision One/20 system. Each is interfaced to one of PDP-11 processors. Additionally, the Vision One/20, with its built-in LSI-11 processor, has considerable stand-alone image processing capabilities.

A variety of operating systems are employed in the Laboratories and their unique hands-on capabilities provide a controllable environment for operating systems research and development. Two operating systems are maintained for general use: UNIX, developed at Bell Laboratories and widely used throughout the academic community, and RSX-11M, a Digital Equipment Corporation operating system and the most popular mini-computer operating system with Navy Laboratories and contractors.

Operating on an ARPANET TIP/PLI, the Command, Control, and Communications Secure Laboratory provides both secure and non-secure access to the ARPANET. A PDP 11/70 with three color graphics stations, six intelligent terminals, tape drives, printers, and 300 mega bytes on mass storage units constitute the system's hardware. Running under the UNIX operating system, this system is equipped with special software to support ARPANET protocols and networking requirements. The Secure Laboratory is available to faculty, staff, and students requiring the capabilities of this laboratory for instruction and research relative to Command, Control, and Communications.

The Computer Laboratories support a variety of courses in Computer Science and Command, Control, and Communications as well as faculty and student research in many areas of mathematics, the sciences, and engineering.

The members of the Laboratories' staff can provide users with technical advice related to the hardware and software associated with each of the Laboratories' computer systems. Their interests and research activities are broad and include such areas as networking, graphics, software engineering, image processing, expert systems, signal processing, computer languages, and operating systems. They are able to assist users with complex hands-on research projects involving both hardware and software interfaces to the systems. In addition, they can provide support to those wishing to use the Laboratories for instructional purposes, which demand the Laboratories' unique capabilities.

OTHER COMPUTER RESOURCES

Almost all of the academic departments have their own minicomputers to provide specialized computing support or to dedicate to specific applications or areas of research. These systems include Electrical Engineering (NOVA 800, PDP 11/40 and 11/34s, Interdata 7/32), Mechanical Engineering (Tek 4081), Aeronautics (IBM Series 1), Physics & Chemistry (Interdata 70), Oceanography (PDP 8/S) and Operations Research (PDP 8/E).

Also, great use is made of micro-computers as stand-alone development tools or as processing elements imbedded in more complex systems. Although all departments are active, Computer Science and Electrical Engineering both have laboratories of microprocessing systems available for teaching and research.

DUDLEY KNOX LIBRARY

Librarian conducting an on-line information search

STAFF

Paul Spinks, Associate Professor and Director of Libraries (1959)*; B.A., Univ. of Oklahoma, 1958; M.S., 1959.

Mary Therese Britt, Assistant Professor and Associate Director of Libraries (1966); B.S., College of St. Catherine, 1947.

Arthur Edward Cassidy, Acquisitions Librarian (1981); B.A., Rutgers Univ., 1957; M.S., 1962; M.A., Univ. of Florida, 1972; M.S., California State Univ. at San Jose, 1980.

Pasco Domenic Collelo, Research Reports Librarian (1973); B.S., Brown Univ., 1951; M.A., California State Univ. at San Jose, 1972.

Richard Eugene Hanna, Reference Librarian (1979); B.A., Univ. of California at San Diego, 1971; M.S., Univ. of Hawaii, 1973.

Noel William Johnson, Assistant Professor and Head Cataloging Librarian (1970); B.A., Univ. of Nevada, 1949; B.S., Univ. of California at Berkeley, 1954.

Kevin John McHugh, Cataloging Librarian (1980); B.A., Loyola Univ., 1948; M.A., 1952; M.S., Univ. of Missouri, 1980.

Roger McQueen Martin, Reader Services Librarian (1974); B.S., Univ. of Texas, 1949; M.S., 1958.

Diane Shirley Nixon, Head Acquisitions Librarian (1969); B.A., California State Univ. at Fullerton, 1968; M.S., Univ. of Southern California, 1969.

Louis Oven, Cataloging Librarian (1969); B.A., Monterey Institute of Foreign Studies, 1964; M.A., Univ. of California at Berkeley, 1968.

Frances Emanuela Maria Strachwitz, Research Reports Librarian (1970); B.S., Dominican College of San Rafael, 1951; M.A., Univ. of Denver, 1968.

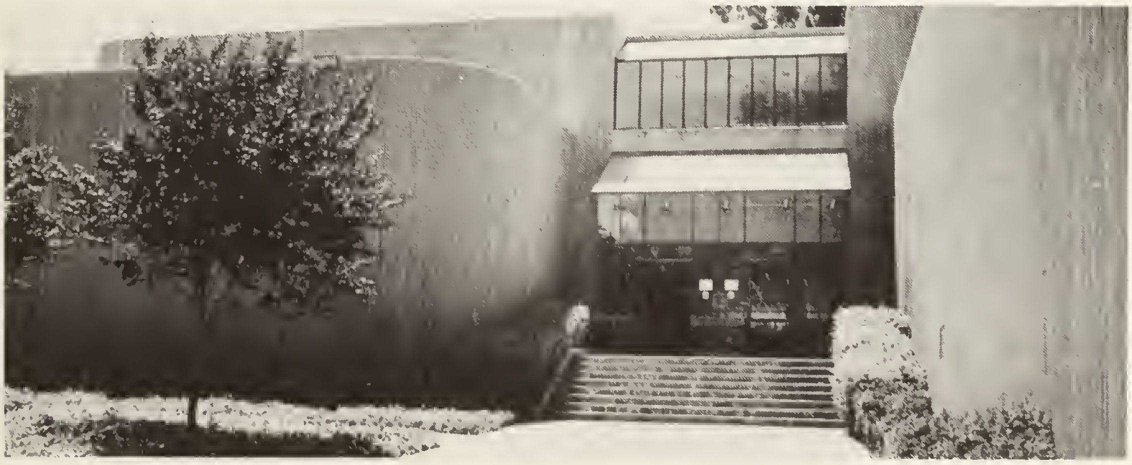
**The year of joining the Postgraduate School is indicated in parentheses.*

The Dudley Knox Library, a building of 50,000 square feet, was dedicated in 1972. The collections housed therein serve the research and instructional needs of the community, comprising students, faculty, and staff of all departments of the Postgraduate School. They embrace an active collection of 210,000 books, bound periodicals, government documents, and pamphlets; 32,000 monographic and journal items in microform; 168,000 research reports in hard copy and 248,000 in microform; and over 1,800 periodicals and other serial publications currently received. These materials parallel the School's curricular fields of engineering, physical sciences, managerial sciences, operations research, naval sciences, and national security affairs.

The Reader Services Division provides the open literature sources, such as books, periodicals and journals, indexes and abstracting services, pamphlet materials and newspapers. It provides access to more than 100 computer data bases in the curricular fields of interest by means of CIRC, Foreign Technology Division Center, AFSC, Wright-Patterson Air Force Base, DIALOG, Lockheed Information Systems, INFORMATION BANK, New York Times, ORBIT, SDC Search Service, and RLIN, Stanford University. It furnishes facilities for microform reading and printing and for reproduction of printed matter. It borrows publications not held in its collections from other libraries.

The Research Reports and Classified Materials Division is the principal repository for research documents received by the School. It houses the Library's classified and unclassified research reports in hard copy and microfiche. A machine information storage and retrieval system that utilizes the School's computer facilities is available for bibliographic searches of research and development documents held by the division. An SDI (Selective Dissemination of Information) Service is also available. In addition, the Division is able to perform, via its own remote terminal, computer searches of the data banks of the Defense Technical Information Center in Alexandria, Virgina, and thus to provide rapid and efficient access to the 1,000,000 plus documents held by the Center.

The Christopher Buckley, Jr., Library is located on the second floor of the Library. It is a collection of some 8,000 volumes pertaining principally to naval history and the sea. This collection was donated to the Naval Postgraduate School through the interest and generosity of the late Mr. Christopher Buckley.



Dudley Knox Library, North Entrance

CURRICULAR OFFICES AND PROGRAMS

The curricular offices are staffed by military Curricular Officers and civilian-faculty Academic Associates. They share the responsibility of developing, maintaining and updating curricular programs that are academically sound and meet the professional needs of the Department of Defense. Each officer student is assigned to an appropriate curricular office for academic and military counseling and supervision.

This section of the catalog includes descriptions of all regularly sponsored curricula offered at the Naval Postgraduate School. Specific academic requirements for enrollment are contained within the portion relating to each curriculum. In general, the more technical curricula require mathematics through calculus and varying levels of scientific or engineering courses.

Students with academic deficiencies in mathematics or science are encouraged to take advantage of the Naval Postgraduate School's Continuing Education offerings. An opportunity also exists for some students to enter a technical curriculum as indirect inputs via the Engineering Science Program (#460). This preparatory program for one or two quarters' duration, is tailored to each student's needs.

The curricular programs typically include an introductory phase wherein a student completes the required preparatory courses before undertaking graduate-level studies. Many of the preparatory courses are available for off-campus self-study through the Office of Continuing Education.

Prospective students are encouraged to communicate with the cognizant Curricular Officer by letter or telephone for counseling regarding the particular off-campus courses they may require to qualify for enrollment in a given curriculum and those that would serve to strengthen their preparation for its graduate program.

CURRICULAR OFFICES

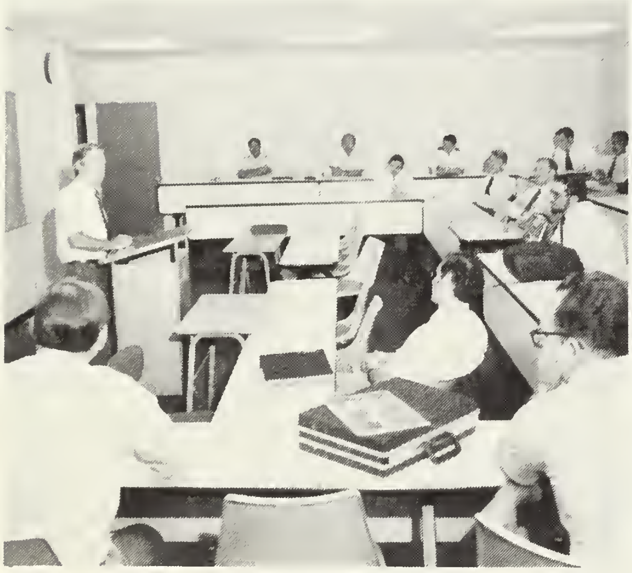
Title	*Organizational Code*	*AUTOVON*
Administrative Science	36	878-2536
Aeronautical Engineering	31	878-2491
Air-Ocean Science	35	878-2044
Antisubmarine Warfare	331	878-2116
Command, Control, and Communications (C3)	39	878-2772
Computer Technology	37	878-2174
Electronics and Communications	32	878-2056
National Security Affairs/Intelligence	38	878-2228
Naval Engineering	34	878-2033
Operations Analysis	30	878-2786
Weapons Engineering	33	878-2116

CURRICULA

Curriculum	*Curriculum Number*	*Normal Length (Months)*	*Normal Convening Dates*	*Cognizant Curricular Office Code*
Administrative Science				
(Material Movement)	813	12-18	July	36
(Acquisition & Contract Management)	815	12-18	January, July	36
(USMC, USCG, USA, and Allied Officers)	817	12-18	January, July	36
(Systems Inventory Management)	819	12-18	January, July	36
(Material Logistics Support)	827	12-18	January, July	36
(Financial Management)	837	12-18	January, July	36
(Manpower/Personnel Training Analysis)	847	12-18	January, July	36
(Human Resources Management)	857	12-18	January, July	36
Aeronautical Engineering	610	18-24	Any Quarter	31
Aeronautical Engineering Avionics	611	18-24	Any Quarter	31
Air-Ocean Science	373	18-24	Any Quarter	35
Air-Ocean Tactical Environmental Support	374	18-24	Any Quarter	35
Antisubmarine Warfare	525	24	March, October	331
Command, Control, and Communications (C3)	365	18	October	39

Curriculum	*Curriculum Number*	*Normal Length (Months)*	*Normal Convening Dates*	*Cognizant Curricular Office Code*
Communications Engineering	600	21-27	Any Quarter	32
Computer Science	368	18-21	March, October	37
Computer Systems	367	12-15	March, October	37
Electronic Warfare Systems Technology	595	21-24	October	32
Engineering Electronics	590	21-27	Any Quarter	32
Engineering Science		6	March, October	- -
Intelligence	825	18	March, October	38
Meteorology	372	18-24	Any Quarter	35
National Security Affairs				
(Middle East, Africa, South Asia)	681	12-24	January, July	38
(Far East, Southeast Asia, Pacific)	682	12-24	January, July	38
(Europe, USSR)	683	12-24	January, July	38
(International Organizations and Negotiations)	684	12-18	January, July	38
(Strategic Planning - General)	686	12-18	January, July	38
(Strategic Planning - Nuclear)	687	12-18	January, July	38
Naval Engineering	570	18-27	Any Quarter	34
Oceanography	440	18-24	Any Quarter	35
Oceanography (Hydrography)	441	18-24	Any Quarter	35
Operations Analysis	360	18-24	March, October	30
Telecommunications Systems Management	620	18	October	32
Underwater Acoustics	535	18-27	October	33
Weapons Systems Engineering	530	18-27	March, October	33
Weapons Systems Science	531	18-27	March, October	33

ADMINISTRATIVE SCIENCE PROGRAMS CURRICULA NUMBERS
813, 815, 817, 819, 827, 837, 847, 857



Richard Bray Renner, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1957; M.S., Naval Postgraduate School, 1975.

James Kenichi Arima, Associate Professor of Economics; Academic Associate (Manpower/Personnel Management-847); B.A., Univ. of California at Los Angeles, 1948; M.A., George Washington Univ., 1957; Ph.D., Northwestern Univ., 1962.

Dan Calvin Boger, Assistant Professor of Economics; Academic Associate (Material Movement-813 and USMC Defense Systems Analysis-817); B.S., Univ. of Rochester, 1968; M.S., Naval Postgraduate School, 1969; M.A., Univ. of California at Berkeley, 1977; Ph.D., 1979.

Carson Kan Eoyang, Associate Professor of Management; Academic Associate (Human Resources Management-857); B.A., Massachusetts Institute of Technology, 1966; M.B.A., Harvard Univ., 1968; Ph.D., Stanford Univ., 1976.

Kenneth James Euske, Assistant Professor of Accounting; Academic Associate (USCG Management Science-817); A.B., Gonzaga Univ., 1967; M.B.A., Dartmouth College, 1969; D.B.A., Arizona State Univ., 1978.

James Morgan Fremgen, Professor of Accounting; Academic Associate (Financial Management-837); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., State of Indiana, 1964.

Reuben Travis Harris, Associate Professor of Organizational Behavior & Management; Academic Associate (Administrative Science for Allied Students-817); B.S., Antioch College, 1969; M.B.A., Univ. of Rochester, 1972; Ph.D., Stanford, 1975.

James Kern Hartman, Associate Professor of Operations Research; Academic Associate (Administrative Science Programs-817); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

David Vincent Lamm, Commander, U.S. Navy; Assistant Professor of Administrative Sciences; Academic Associate (Acquisition and Contract Management-815); B.A., Univ. of Minnesota, 1964; M.B.A., George Washington Univ., 1972; D.B.A., 1976.

Alan Wayne McMasters, Associate Professor of Operations Research & Administrative Sciences; Academic Associate (Systems Inventory Management-819 and Material Logistics Support-827); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

ADMINISTRATIVE SCIENCE CURRICULA (GROUP MN)

CURRICULUM 813 — Material Movement
CURRICULUM 815 — Acquisition and Contract Management
CURRICULUM 817
  Allied Officer — Various Management Options
  U.S. Army — Operations Research Systems Analysis (Business)
  U.S. Marine Corps — Defense Systems Analysis
  U.S. Coast Guard — Management Science
CURRICULUM 819 — Systems Inventory Management
CURRICULUM 827 — Material Logistics Support
CURRICULUM 837 — Financial Management
CURRICULUM 847 — Manpower/Personnel Training Analysis
CURRICULUM 857 — Human Resources Management

OBJECTIVES — These programs are designed to:

— provide the officer with the specific functional skills required to effectively manage in a subspecialty area.

— provide the officer with the Navy/Defense Systems oriented graduate management education.

— enable the officer to evaluate the written research, study, and analysis product of others throughout his career.

— provide the officer with fundamental interdisciplinary techniques of quantitative problem-solving methods, behavioral and management science, economic analysis, and financial management.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above average grades is required. Completion of at least two semesters of college mathematics at the level of college algebra or trigonometry is considered to be the minimum mathematical preparation.

DESCRIPTION — These curricula are interdisciplinary programs which integrate mathematics, accounting, economics, behavioral science, management theory, operations/systems analysis, and a subspecialty concentration area into an understanding of the process by which the defense mission is accomplished. Subspecialty concentration areas are specified by ordering officers into a specific curriculum.

Officers successfully completing the program will be awarded the degree of Master of Science in Management. In addition, Naval officers who complete one of the approved programs are awarded an appropriate subspecialty code (p-code).

Officers from the U.S. Services as well as allied officers start the curriculum with widely varied academic backgrounds. Each student's prior academic work and related military experience is evaluated for courses previously completed and applicable to the student's curriculum so that academic credits may be transferred. Validation or credit by examination is encouraged where knowledge of the material has been acquired by experience or service courses. A course load of 16 credit hours per quarter will be programmed.

FUNDAMENTALS PROGRAM

This portion of the curriculum is generally preparatory in nature and portions of it may be validated by the officer with appropriate experience or academic background. The courses contained in the Fundamentals Program are considered prerequisites to the four quarters of graduate work. Officers can enhance their selectability for Administrative Science curricula by completing prerequisite courses, or their equivalents, through off duty education, including courses available through the NPS Office of Continuing Education.

The Fundamentals Program offers the following areas of study:

Mathematics for management and probability
Micro and macro economics
Financial and managerial accounting
Individual and organizational behavior (organizational systems)
Introduction to computers
FORTRAN programming

GRADUATE PROGRAM

The general Graduate portion of each program includes courses in the following areas:

Statistics
Operations research for management
Public policy processes
Policy analysis
Management information systems
Personnel management and labor relations
Management policy

Specific courses pertaining to the various curricula include the following:

Material Movement
(813)

Curriculum Courses
Material logistics
Transportation management
Transportation policy
Decision making for financial management
Electives
Contract management and administration
Production management
Selected topics in logistics
Introduction to systems acquisition and project management

Acquisition and Contract Management (815)

Curriculum Courses
Principles of acquisition and contracting
Contract pricing and negotiations
Decision making for financial management
Contract administration
Acquisition & contract policy
Electives
Material logistics
Production management
Cost accounting
Defense industries

Defense Systems Analysis
(817-USMC)

Curriculum Courses
Contract management & administration
Financial management in the Armed Forces
Cost accounting
Electives

— Two from List A, one from List B. Substitutes with permission of Marine Corps Representative and the Curricular Officer.

LIST A
- Analysis of bureaucracy
- Internal control and financial auditing
- Decision making for financial management
- Auditing in the public sector

LIST B
- Manpower economics
- Decision analysis
- Public expenditure analysis
- Microeconomic theory and policy
- Theory of systems analysis

Management Science (817-USCG)

Required Courses
- Personnel management processes I
- Personnel management processes II
- Financial control systems

Curriculum Courses

(select available electives minimum of 3 of the 4 groups)

GROUP 1
- Decision analysis
- Search theory and detection
- Data analysis
- System simulation

GROUP 2
- Manpower requirements determination
- Planning and control
- Leadership and group behavior
- Other manpower personnel management courses

GROUP 3
- Introduction to systems acquisition and project management
- Manpower economics I, II
- Cost accounting
- Theory of systems
- Public expenditure policy and analysis

GROUP 4
- Contract management and administration
- Material logistics
- Internal control and financial auditing
- Decision making for financial management
- Acquisition and contracting policy
- Auditing in the public sector

Operations Research/Systems Analysis Business (817-USA)

Fundamentals Required courses
- Computational matrix algebra*
- Calculus and vector analysis*

**These replace math for management and probability.*

Curriculum Required Courses
- Linear Programming
- Operations research of Army weapons systems
- Probability and statistics for management I,II

Curriculum Elective Courses (Choice of Three)
- Stochastic models
- Combat models
- Cost estimation
- Nonlinear and dynamic programming
- Networks, flows and graphs
- Inventory
- Operations research methodology
- Human factors in systems design
- Decision analysis

General Management for Allied Officers (817)

This curriculum offers officers from allied nations the opportunity and flexibility to design a graduate program in management which will best meet the special needs of the allied country and the unique capabilities of the individual officer. As with all administrative science department curricula, this program requires completion of the fundamentals program, all required core graduate courses and submission of an acceptable thesis. However, unlike other curricula, this program allows students, with the guidance of a faculty academic associate, to select any mix of graduate management courses which satisfy credit hour requirements for graduation. Students may design very specialized programs, through selecting all elective courses within a single discipline or they may design a very broad general management program cutting across the numerous management disciplines. Allied officer students in this curriculum are encouraged to conduct their thesis research in an area of relevance and direct application to their home nations and sponsoring organizations. Field trips and travel for thesis research are considered an integral part of the educational process.

Systems Inventory Management (819)

Curriculum Required Courses
- Material logistics
- Decision making for financial management
- Inventory I
- Seminar in supply systems

Curriculum Elective Courses
- Material handling system design
- Production management
- Transportation management
- Contract management & administration
- Introduction to systems acquisition and project management

Material Management (827)

Curriculum Courses
- Aviation Maintenance Duty Officers:
  - Material logistics
  - Production management
- Supply Corps Officers:
  - Decision making for financial management
  - Material logistics
  - Production management

Curriculum Elective Courses
- Contract management & administration
- Introduction to systems acquisition and project management
- Logistics engineering
- Maintainability engineering
- Quality assurance reliability
- Transportation management
- Inventory I

Financial Management (837)

Curriculum Required Courses for U.S. Navy Officers
- Decision making for financial management*
- Financial management in the Armed Forces
- Financial management control systems

(required for Supply Corps officers; elective for all others)

Curriculum Elective Courses
- Planning and control: measurement and evaluation
- Analytical techniques for control and planning
- Auditing in the public sector
- Accounting theory/standards
- Internal control and auditing
- Cost accounting
- Public expenditure analysis
- Applications of management information systems

Manpower/Personnel Training Analysis (847)

Curriculum Required Courses
- Training requirements management
- Personnel management process I, II
- Manpower economics I, II
- Manpower/personnel policy analysis
- Manpower and personnel models
- Manpower requirements determination

Curriculum Electives
- Personnel performance evaluation
- Personnel motivation
- Personnel selection and classification
- Personnel training

Human resources Management (857)

Curriculum Required Courses
- Behavior research methodology
- Organization development I, II
- HRM field work
- Education and training
- Organization theory

Curriculum Electives
- Planning and control
- Leadership and group behavior
- Sociological analysis
- Personnel performance evaluation
- Personnel motivation
- Industrial relations

THESIS RESEARCH

Twelve quarter hours are allocated for thesis research over the last two quarters of the Graduate Program. The thesis subject will be appropriate to the subspecialty area being prepared for.

AERONAUTICAL ENGINEERING PROGRAMS
CURRICULA NUMBERS
610 AND 611

William Hayes Goesling, Commander, U.S. Navy; Curricular Officer; B.S. in Chemistry, Univ. of Montana, 1963; M.S. in Applied Science, Naval Postgraduate School, 1977; M.S. in Management, 1977.

Robert Diefendorf Zucker, Associate Professor of Aeronautics; Academic Associate; B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

OBJECTIVE — To provide advanced professional knowledge in the field of Aeronautical Engineering.

ENTRANCE REQUIREMENTS — The following are required for direct entry:

1. A baccalaureate degree or its equivalent, with an above average QPR, preferably in engineering or the physical sciences.
2. Mathematics through differential and integral calculus, with above average grades.
3. Completion of a calculus based physics sequence with above average grades.

The Engineering Science Program (Curriculum 460) is available for candidates who do not meet all the admission requirements for direct entry.

WHO CAN ATTEND — Naval aviation officers, officers of other U.S. services, and civilian employees of the U.S. federal government. Allied officers may also enroll, subject to the exclusion of particular classified courses.

DEGREE EARNED — Master of Science in Aeronautical Engineering is included as part of the program. (Advanced programs are available through the Doctorate for a few selected students.)

NAVY
NAVY
401

DURATION OF PROGRAM — Up to two years, for direct entry students, depending on their background and ability.

ENTRANCE DATES — Students may enter an Aero program any quarter of the academic year. However, those entering via the Engineering Science Program should enter Curriculum 460 in March or October for more effective program sequencing.

DESCRIPTION — The Aeronautical Engineering Programs are designed to meet the specific needs of the Navy's Operational Technical Managerial System (OTMS) for technical managers with a broad-based graduate education in Aeronautical Engineering. The opportunity for aviation officers to enroll in one of the Aeronautical Engineering Programs is dependent on a number of factors, including personal motivation and preference, professional performance, academic background, needs of the Service, and officer availability. While an undergraduate degree in engineering is naturally preferred, special preparatory programs can accommodate officers with widely varying academic backgrounds. Included among the long list of "Aero" graduates are many officers who entered with non-engineering degrees in fields such as Music and History.

All Navy graduate programs exist solely to support the validated OTMS billet requirements. For each program there is a Navy consultant charged with the responsibility of identifying the educational skills to be covered by that program. For the Aeronautical Engineering Programs, the primary consultant is the Commander, Naval Air Systems Command (NAVAIR), and the subspecialty code assigned to graduates is either XX71P or XX72P. As with other programs at the Naval Postgraduate School, the consultant-identified educational skill requirements for the Aeronautical Engineering Programs exceed the traditional requirements for a Master's degree. Therefore, while qualifying for a subspecialty code in aeronautical engineering, all "Aero" students also satisfy the academic requirements for the degree Master of Science in Aeronautical Engineering.

PREPARATORY PHASE

Preparation for graduate study is tailored to each officer's background and is programmed for a minimum time consistent with his capability. Each student's academic transcript is evaluated for possible validation of courses in areas where a sufficiently strong record of achievement is evident. Validation or credit by examination is also possible.

Some of the subject matter in the preparatory program is available for off-campus study through the Continuing Education Office. All such Aero material is structured in "mini-courses" of one credit hour to encourage rapid completion. Each officer is urged to complete as much of this material as possible before arriving on campus.

The following material represents the minimum coverage required for entry into the graduate phase:

Linear algebra and vector analysis
Calculus and differential equations
Fluid-thermo-gasdynamics
Flight structures and dynamics
Aerodynamics-performance-stability
Circuit theory and electronics
Computer programming
Basic aero labs

GRADUATE CORE

After the preparatory program, students enter into a common Graduate Core designed to provide advanced knowledge in each of the four principal areas of aeronautics:

Aircraft and missile propulsion
Current aerodynamic analysis
Flight vehicle structural analysis
Stability and control of aerospace systems

In addition to the above, the Graduate Core includes work in material science and advanced Aero laboratories together with extensive study of computer methods.

ADVANCED GRADUATE PHASE

All students receive in-depth graduate coverage through elective courses in the following areas:

FLIGHT DYNAMICS — Covers the stability and control parameters of a flight vehicle, including optimal control, fly by wire, aeroelastic effects, flight evaluation techniques, and VSTOL technology.

FLIGHT PROPULSION — Covers the analysis of propulsion devices for aircraft and missiles along with current methods in the design of turbomachines.

GASDYNAMICS — Covers internal and external flows in the subsonic, transonic, supersonic and hypersonic regimes, including plasma flows and laser technology.

FLIGHT STRUCTURES — Covers the behavior of structural components under static and dynamic loads, including current design methodology and use of advanced fabrication techniques.

An important feature of all Aero programs is a comprehensive sequence in aircraft/missile design which comes near the end of the program.

Highlighting the final phase of Curriculum 611, Aeronautical Engineering-Avionics, are sequences in the following areas:

Guidance and control
Aero-computer science (with
  emphasis on microprocessor
  applications)
Microwave applications

Overall, approximately 75% of the course work in Curriculum 610 is common to Curriculum 611, and the degree awarded in both is the Master of Science in Aeronautical Engineering.

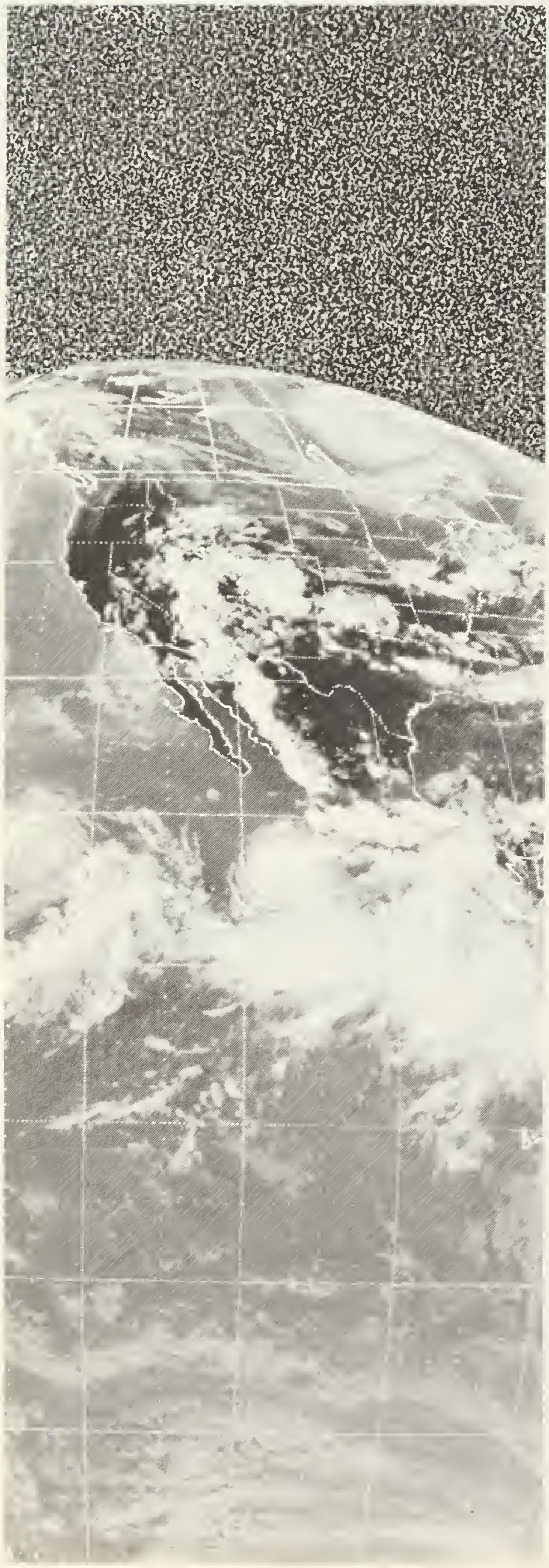
Each student conducts research and prepares a thesis on a topic of his choice in areas such as: manned and unmanned flight vehicles, automatic landing systems, control of flight vehicles from hovering flight to hypersonic reentry, aircraft survivability and vulnerability, blast and shock effects, flight vehicle computer applications, electro-optics, or laser technology.

Extensive laboratory and computer facilities are available to supplement instructional and thesis research programs. In addition to the technical courses that form the structure of the graduate program and satisfy degree requirements, each student takes courses which are particularly relevant to Navy needs and professional development.

PROPULSION · LABORATORY

Cutting ribbon for addition to Turbopropulsion laboratory

AIR-OCEAN SCIENCES
PROGRAMS
CURRICULA NUMBERS
372, 373, 374, 440, 441



Carl Bolton Ihli, Jr., Lieutenant Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1968; M.S. in Meteorology and Oceanography, Naval Postgraduate School, 1977.

Robert George Paquette, Professor of Oceanography; Academic Associate (Oceanography); B.S., Univ. of Washington, 1936; Ph.D., 1942.

Robert Lee Haney, Associate Professor of Meteorology; Academic Associate (Meteorology); A.B., George Washington Univ., 1964; Ph.D., Univ. of California at Los Angeles, 1971.

METEOROLOGY CURRICULUM NUMBER 372

OBJECTIVE — To provide qualified personnel with a sound understanding of the science of meteorology and to develop the technical expertise to provide, and utilize, meteorological and oceanographic data in support of all aspects of military operations.

This education enhances performance in all duties throughout a career including operational billets, technical management assignments, and policy making positions. Personnel will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their professional career.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with at least average grades in mathematics and the physical sciences is required. Completion of mathematics through differential and integral calculus and one year of college physics is considered to be minimal preparation. The program is open to Air Force Officers, Allied Officers, and qualified federal employees. The curriculum is not open to U.S. Naval officers.

DESCRIPTION — The Meteorology Curriculum is interdisciplinary in nature and encompasses those areas of meteorology which are directly related to environmental support of operations. The program consists of preparatory subjects and course sequences in synoptic and dynamic meteorology and numerical prediction. The program recognizes the interaction of the atmosphere and the ocean and deals with the important relationships at the air/sea interface.

Classroom instruction is supplemented by laboratory exercises, computer solutions to problems, and guest lecturers and seminars. Upon completion of the program, the student is qualified to serve independently as a meteorological forecaster. By completing a required thesis, he is introduced to the problems associated with independent research. Successful completion of the program leads to the awarding of the degree of Master of Science in Meteorology.

Matriculation may occur any quarter each year. Although the program is designed for seven academic quarters, students qualified may have this period shortened by validation of courses previously taken, transfer of credits, and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education.

INTRODUCTORY STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

Linear algebra and vector analysis
Differential equations
Partial differential equations
Numerical analysis
Introduction to meteorology
Computer science fundamentals
Applied probability and statistics

GRADUATE CORE

BASIC DYNAMIC AND PHYSICAL METEOROLOGY SEQUENCE:

Geophysical thermodynamics
Heat transfer processes
  Air-Ocean fluid dynamics
Dynamic meteorology
Air/Sea interaction
Numerical air-ocean modeling
Atmospheric factors in electromagnetic and electro-optic propagation

METEOROLOGICAL ANALYSIS AND FORECASTING SEQUENCE:

Meteorological analysis
Tropospheric and stratospheric meteorology
Tropical meteorology
Weather forecasting
Mesoscale meteorology

METEOROLOGICAL ELECTIVES:

Advanced geophysical fluid dynamics
Advanced tropical meteorology
Advanced numerical weather prediction
General circulation of the atmosphere/oceans
Remote sensing/satellite observations
Polar meteorology/oceanography

Ample time is provided for students to complete research for a thesis in the area of their primary interest. Elective courses are also available in the areas of oceanography, computer science, or operations research.

AIR-OCEAN SCIENCE CURRICULUM NUMBER 373

OBJECTIVE — To provide qualified personnel with a thorough understanding of the air-sea environment and to develop the technical expertise to provide and utilize meteorological and oceanographic data and knowledge in support of all aspects of military operations.

This education enhances performance in all duties throughout a career including operational billets, technical management assignments and policy making positions. Students will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their careers.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree in meteorology, or oceanography, or the equivalent. While this curriculum is open to officers of the other U.S. military services, allied officers, and civilian employees of the U.S. federal government, its availability to U.S. Navy officers is limited to those of the Restricted Line (Special Duty — Geophysics). Additionally, Navy officer students in the Air-Ocean Tactical Environmental Support Curriculum may, upon change of designator, transfer into the Air-Ocean Science Curriculum. Students who successfully complete this curriculum will be awarded the XX47P subspecialty billet code.

DESCRIPTION — The Air-Ocean Science Curriculum (373) is interdisciplinary in nature and encompasses those areas of meteorology and oceanography which are directly related to environmental support of military operations. The program consists of preparatory subjects, basic courses in dynamic and physical meteorology and oceanography, and a sequence in environmental analysis and forecasting, including numerical methods by computer. The program recognizes the importance of interactions between the atmosphere and the oceans, and deals with the relationships at the air/sea interface.

Classroom instruction is supplemented by laboratory exercises, field experience, computer solutions to problems, and guest lectures and seminars. Each student is required to complete a satisfactory thesis. In so doing the student is introduced to the problem of applying his theoretical knowledge to the solution of a practical problem. Upon completion of the program the student is qualified to serve independently as a meteorological and oceanographic forecaster in support of operations.

Matriculation may occur any quarter each year. A typical program for students with a baccalaureate degree in either meteorology or oceanography is eight quarters. However, students may have this period shortened by validation of courses previously taken, transfer of credits, and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education.

Successful completion of the program leads to the awarding of the degree of Master of Science in Meteorology and Oceanography.

INTRODUCTORY STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

Linear algebra and vector analysis
Differential equations
Partial differential equations
Computer science fundamentals
Numerical analysis
Air-Ocean statistics

GRADUATE CORE

BASIC DYNAMIC AND PHYSICAL METEOROLOGY AND OCEANOGRAPHY SEQUENCE:

Physical oceanography
Biogeochemical processes in the ocean
Synoptic oceanography
Physics of sound in the ocean
Ocean influences in underwater acoustics
Meteorological analysis
Geophysical thermodynamics
Heat transfer processes
Air-Ocean fluid dynamics
Dynamical meteorology
Dynamical oceanography
Air-Sea interaction
Numerical air-ocean modeling

METEOROLOGICAL AND OCEANOGRAPHIC ANALYSIS AND FORECASTING SEQUENCE:

Acoustic forecasting
Wave and surf forecasting
Forecasting weather elements
Tropical meteorology
Tropospheric and stratospheric analysis
Ocean circulation analysis
Atmospheric factors in electromagnetic and electro-optic propagation
Air-Ocean data networks

BASIC COURSES IN MAPPING, CHARTING AND GEODESY (MC&G):

Mapping, charting and geodesy
Hydrographic and geodetic surveying

Included in the program is a specialization option in either meteorology, oceanography or MC&G consisting of the following courses:

METEOROLOGY OPTION

Mesoscale meteorology
Polar meteorology and oceanography
Advanced tropical meteorology
Remote sensing and satellite observations
Atmospheric modeling II
Advanced geophysical fluid dynamics

OCEANOGRAPHY OPTION

Coastal oceanography
Polar meteorology and oceanography
Satellite oceanography
Advanced synoptic oceanography
Ocean modeling II
Ocean operations

MC&G OPTION

Photogrammetry and remote sensing
Marine geophysics
Geometric and astronomic geodesy
Gravimetric and satellite geodesy
Tides
Hydrographic operations

An integral part of the program is the six-week Geophysics Technical Readiness Laboratory in which Geophysics officers are further involved in the application of meteorology, oceanography and MC&G to fleet operations through the use of a structured set of realistic scenario exercises.

AIR-OCEAN TACTICAL ENVIRONMENTAL SUPPORT CURRICULUM NUMBER 374

OBJECTIVE — To provide students with a thorough understanding of the air-sea environment and operations analysis principles to forecast atmospheric, oceanic, and acoustic conditions in support of all aspects of Naval operations including the ASW, EW and C3 problems. Primary emphasis is placed on the understanding of the impact of the environment (atmosphere, ocean and their interface) on weapons systems, sensors and platforms. The program recognizes the importance of interactions between the atmosphere and the oceans, and deals with the relationships at the air-sea interface.

This education enhances performance in all duties including operational billets, technical management assignments, and policy making positions. Students will develop sound graduate level technical ability based on general engineering and scientific principles, develop analytical ability for tactical problem solving, broaden their capacity for original thought, and in general, enhance their performance in all aspects of their professional careers.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or equivalent with above average grades in mathematics and the physical sciences if required. Completion of mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry are required.

The Curriculum is open to all Navy officer communities (surface, sub-surface, and aviation), officers of other U.S. services, allied officers and civilian employees of the U.S. federal government. Students who successfully complete this curriculum will be awarded the XX49P subspecialty billet code.

DESCRIPTION — The interdisciplinary Air-Ocean Tactical Environmental Support curriculum provides a firm foundation in meteorology and oceanography with an emphasis on the tactical environmental support of military operations. The program consists of preparatory numerical and statistical analysis subjects, basic courses in dynamical and physical meteorology and oceanography, a sequence in air-ocean analysis and forecasting, including numerical methods by computer, and a sequence in tactical environmental support.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. The Research Vessel ACANIA is sponsored by the Oceanographer of the Navy for class laboratory experience as well as for individual research efforts. Guest lectures, seminars and field trips serve to round out the curriculum. The Fleet Numerical Oceanography Centers serves as a focal point for Air-Ocean Science operations and applied research. Each student is required to complete a thesis. In so doing, he is introduced to research methods, develops his technical writing skills, completes a project of several quarters duration requiring initiative and originality, and often solves a problem of scientific interest and practical value to the Navy. Upon completion of the program, the student is qualified to independently serve as a meteorological and oceanographic forecaster in support of military operations.

Matriculation may occur any quarter of the year. Although the program is designed for eight quarters, qualified students may have this period shortened by validation of courses previously taken, transfer of credits, and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education. Successful completion of the program leads to the awarding of the degree of Master of Science in Meteorology and Oceanography.

INTRODUCTORY STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

Linear algebra and vector analysis
Differential equations
Partial differential equations
Computer science fundamentals
Air-Ocean statistics

GRADUATE CORE

DYNAMIC AND PHYSICAL METEOROLOGY AND OCEANOGRAPHY SEQUENCE:

Physical oceanography
Biogeochemical processes in the ocean
Physics of sound in the ocean
Ocean influences in underwater acoustics
Meteorological analysis
Geophysical thermodynamics
Air-Ocean fluid dynamics
Dynamical meteorology
Dynamical oceanography
Air-Sea interaction
Numerical air-ocean modeling

METEOROLOGICAL AND OCEANOGRAPHIC ANALYSIS AND FORECASTING SEQUENCE:

Acoustic forecasting
Wave and surf forecasting
Forecasting weather elements
Tropospheric and stratospheric analysis
Atmospheric factors in electromagnetic and electro-optic propagation
Air-Ocean data networks

TACTICAL ENVIRONMENTAL SUPPORT SEQUENCE:

Introduction to tactical analysis
Weapons systems and weapons effects
Combat models and gaming
Man-Machine interaction
Search, detection and localization
Radiation systems

OCEANOGRAPHY CURRICULUM NUMBER 440

OBJECTIVE — To provide students with a sound understanding of the science of oceanography, and to develop the technical expertise to provide and utilize oceanographic and acoustical data in support of all aspects of military operations. Particular emphasis is placed on the understanding of oceanographic environmental effects on the solution of the undersea warfare problem.

This education enhances performance in all duties throughout a military career including operational billets, technical management assignments, and policy making positions. Students will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their career.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or equivalent with above average grades in mathematics and the physical sciences is required. Completion of mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry are required. The Program is open to officers of other U.S. Military services, allied officers and qualified civilian employees of the U.S. federal government. *This curriculum is not open to U.S. Naval officers.*

DESCRIPTION — The Oceanography Curriculum 440 is interdisciplinary in nature and encompasses a broad spectrum of physical, chemical, biological, and geological oceanography which is directly related to oceanographic support of military operations.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. The Research Vessel ACANIA is available for class laboratory experience as well as for individual research efforts. Guest lectures and seminars serve to round out the curriculum. Each student is required to complete a satisfactory thesis. In so doing the officer is introduced to the concept of applying theoretical knowledge toward a practical application. Successful completion of this program leads to the awarding of the degree of Master of Science in Oceanography.

Matriculation may occur any quarter of the year. Although the program is designed for eight quarters, qualified students may have this period shortened by validation of courses previously taken, transfer of credits, and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education.

INTRODUCTORY STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

Linear algebra and vector analysis
Differential equations
Partial differential equations
Computer science fundamentals
Air-Ocean statistics
Introduction to meteorology
Biological Oceanography
Chemical Oceanography
Geological Oceanography
Physical oceanography

GRADUATE CORE OCEANOGRAPHY

BASIC PHYSICAL AND DYNAMICAL OCEANOGRAPHY SEQUENCE:

Physics of sound in the ocean
Ocean influences in underwater
  acoustics
Polar oceanography and meteorology
Synoptic oceanography
Advanced synoptic oceanography
Air-Ocean fluid dynamics
Dynamical oceanography
Air-Sea interaction

ANALYSIS AND FORECASTING SEQUENCE:
Acoustic forecasting
Wave and surf forecasting
Coastal oceanography
Air-Ocean data networks
Ocean circulation analysis
Operational environmental products
Regional military oceanography

BASIC COURSES IN MAPPING, CHARTING AND GEODESY (MC&G):

Mapping, charting and geodesy
Hydrographic and geodetic
  surveying

OCEANOGRAPHY (HYDROGRAPHY) CURRICULUM NUMBER 441

OBJECTIVE — To provide students with a sound understanding of oceanography and hydrography. Hydrography (a subdiscipline of mapping, charting and geodesy (MC&G)) is the science of the measurement, description, and charting of the sea floor with special reference to navigation and marine operations. This interdisciplinary program integrates the scientific principles of oceanography with the practical engineering procedures of hydrography. Students achieve the technical expertise to provide and utilize hydrographic data in support of all aspects of hydrographic operations.

This education enhances performance in duties associated with operational billets, technical management assignments, and policy making positions. Students will develop sound graduate level technical ability based on general engineering and scientific principles, develop analytical ability for practical problem solving, broaden their capacity for original thought, and acquire diverse professional knowledge. These qualities will assist in supporting productive achievement throughout their career.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or equivalent with above average grades in mathematics and the physical sciences. Differential and integral calculus, one year of college physics, and one year of college chemistry are required.

The program is open to officers of the National Oceanic and Atmospheric Administration, Coast Guard, Corps of Engineers, allied officers and civilian employees of the U.S. federal government. *The curriculum is not open to U.S. Naval officers.*

DESCRIPTION — The program consists of preparatory subjects, basic courses in numerical and statistical analysis, a dynamics sequence, an analysis and forecasting sequence, and a core of MC&G subjects. The curriculum recognizes the importance of precise positioning systems, error budget analysis, accuracy requirements, data collection methods, and data reduction techniques as applied to the planning, conduct and evaluation of hydrographic, magnetic, and gravity surveys. Graduates will be prepared to make optimum use of the ocean environment in the course of their duties and to carry out and evaluate research in oceanography and hydrography, both basic and applied.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. The Research Vessel ACANIA, sponsored by the Oceanographer of the Navy, is available for class laboratory experience as well as for individual research efforts. Additionally, the National Oceanic and Atmospheric Administration provides laboratory time aboard working hydrographic survey ships. Guest lectures, seminars, and field trips serve to round out the curriculum. Each student is required to complete a thesis. In so doing, he is introduced to research methods, and develops his technical writing skills, while at the same time completing a project of several quarters duration that requires planning, initiative and originality. The student often solves a problem of scientific interest and practical value to his sponsoring agency.

The degree Master of Science in Oceanography (Hydrography) is granted upon successful completion of the program. Matriculation may occur any quarter of the year. A typical program consists of seven quarters. However, highly qualified students may have this period shortened by validation of courses previously taken, transfer of credits, and by completing, prior to enrollment, courses offered by the NPS Office of Continuing Education.

INTRODUCTORY STUDY

Preparatory courses which must be taken or be validated from prior academic work are:

Linear algebra and vector analysis
Differential equations
Partial differential equations
Computer science fundamentals

GRADUATE CORE

BASIC PHYSICAL AND DYNAMICAL OCEANOGRAPHY SEQUENCE:

Physical oceanography
Biogeochemical processes in the ocean
Physics of sound in the ocean
Air-Ocean fluid dynamics
Dynamical oceanography

ANALYSIS AND FORECASTING SEQUENCE:

Analysis of experimental data
Ocean circulation analysis
Coastal oceanography
Electromagnetic and electro-optic propagation

THE MC&G SEQUENCE:

Mapping, charting and geodesy
Hydrographic and geodetic surveying
Hydrographic measurements
Hydrographic cruise
Hydrographic operations
Marine geophysics
Tides
Photogrammetry and remote sensing
Geometric and astronomic geodesy
Gravimetric and satellite geodesy

ANTISUBMARINE WARFARE PROGRAM
CURRICULUM 525

Edward Joseph Mahon, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1957; B.S., Naval Postgraduate School, 1967.

Stephen Matthew Pribula, Commander, U.S. Navy; Assistant Curricular Officer; B.S., Villanova Univ., 1967; M.S., Naval Postgraduate School, 1978.

Otto Heinz, Professor of Physics; Academic Associate; B.A., Univ. of California at Berkeley, 1948; Ph.D., 1954.

OBJECTIVES — This program is designed to:

— Educate officers in the fundamentals of engineering, the environment, and in the use of analytic techniques so that they can understand the basic phenomena which affect the capability of the ASW system(s) for which they are directly responsible.

— Educate officers in the fundamentals of "ASW Systems Engineering" so that they will be able to translate operational requirements into systems effectiveness including the man-machine interface, and to view all of the components of a large system in proper perspective.

— Educate officers in the politico-military and decision-making environment involving Soviet naval activities, net threat assessment and the Washington decision process.

— Develop officers' ability to analyze and develop ASW tactics, to evaluate ASW-related experiences critically, and to state clearly the nature of problems which are associated with ASW systems and operations.

— Provide officers with project-type, practice-oriented experience so that they will develop the ability to relate fundamental concepts directly to ASW operational application.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or equivalent with mathematics through calculus is required for direct input. Courses in the physical sciences and engineering are desirable. An additional qualification for entry into this curriculum is that selectees must have served in at least one ASW mission unit.

Officers not having the required academic qualifications for direct input enter the program via the Engineering Science curriculum discussed elsewhere in this catalog.

Officers may enhance their selectability by taking off-campus courses including participation in the Postgraduate School continuing education program which has been outlined earlier in the catalog.

DESCRIPTION — The structure of the curriculum takes into account the fact that the typical officer student has been away from academic environment for some time and may not be ready to engage in graduate studies without some preparation. The extent of the preparation will depend upon the academic background of the individual officer and will be decided upon by the officer student in consultation with the Curricular Officer and Academic Associate.

The employment of systems in antisubmarine warfare involves complex man-machine interactions; it includes sonar, radar, weapon, communication and information systems and platforms. Therefore, this program is centered around a study of those systems used, and includes extensive breadth in appropriate scientific and technical disciplines. As a culmination of the program, about half of the time in the last six months is devoted to an ASW-related thesis. This provides an opportunity to apply the graduate education and experience to a challenging project which interfaces with current needs in the ASW community.

This interdisciplinary, technical program integrates mathematics, physics, acoustics, electrical engineering, oceanography, operations analysis, human factors, computer science and meteorology. Several short projects are incorporated to further integrate the material presented in lectures and specialized laboratory exercises and to give practice in the systems approach.

The academic content divides naturally into four major discipline areas: Electrical Engineering with emphasis on signal processing; Underwater Acoustics with emphasis on signal propagation and detection; Operations Analysis with emphasis on tactical application and decision analysis, and the Environment with emphasis on the air/ocean interface and environmental factors affecting sound in the sea.

Graduates of the ASW program receive the subspecialty designation XX44P and return to key operationally-oriented ASW billets ashore and afloat. As their careers progress within the Operational-Technical-Managerial Systems (OTMS) concept, they are prepared to perform in all three areas, particularly Operations, and will typically qualify for the Additional Qualification Designator (AQD) of ASW expert. Graduates are awarded the degree Master of Science in Systems Technology.

INTRODUCTORY STUDY

This portion of the program is generally preparatory in nature and some portions of it may be validated by the officer with appropriate operation and academic experience. Because of the integrated nature of the course work in this curriculum, however, validation will be certified only after careful consideration and consultation with the Curricular Officer and Academic Associate.

Undergraduate courses are chosen to prepare students for graduate level work and typically cover the following areas:

Elements of linear algebra, ordinary differential equations, and Fourier series
Vector calculus
Partial differential equations and transforms for wave propagation

- Applied probability theory
- Descriptive statistics and operations research models
- Calculation and programming
- Computer systems
- Electronic systems
- Survey of oceanography
- Threat analysis
- Physics of sound in the ocean
- Meteorology for ASW

GRADUATE STUDY

This portion consists of integrated course offerings in the several disciplines related to ASW. Typical graduate level topics are listed below:

- Study project on ASW systems performance
- Electromagnetic wave propagation
- Non-acoustic sensor systems
- The defense decision process and ASW Warfare
- Computation and computer simulation
- Fundamentals of acoustics
- Underwater acoustics
- Environmental factors in underwater acoustics
- Environmental prediction for underwater sound propagation
- Signals and noise
- Signal processing systems
- Search, detection and localization models
- Combat models and weapons effectiveness
- Decision analysis and data analysis
- Human vigilance performance
- Systems psychology
- Intelligence

In addition to an ASW-related individual thesis or group project as the culmination of the program, each officer selects a two-course elective sequence in a specialty area. Examples of such areas are Operations Analysis, Underwater Acoustics, ASW Signal Processing, Human Factors, and Non-Acoustic Sensors.

Active guest lecture and seminar programs keep students abreast of new developments and "state of the art" technology. Organized field trips expose students to present day applications of theory learned in the classroom. These presentations along with a six-week experience tour (occurring in the fifth quarter) to one of the Navy's research, development, test and evaluation facilities, provide an outstanding opportunity for the student to participate in the development of equipment, procedures, or tactics. This integrated program of theory, labs, seminars, field trips, experience tours, group projects and thesis work, creates a firm background of professional knowledge which is directly applicable to the ASW subspecialty area.

This program convenes biannually in March and October.

COMMAND, CONTROL AND COMMUNICATIONS (C3) PROGRAM
CURRICULUM NUMBER 365

Jeffrey Wade Johnson, Lieutenant Colonel, U.S. Air Force; Curricular Officer; B.S., U.S. Air Force Academy, 1964; M.S. in Operations Research, Texas Tech University, 1972.

Glenn Frank Lindsay, Associate Professor of Operations Research; Academic Associate; B.Sc., Oregon State Univ., 1960; M.Sc., Ohio State Univ., 1962; Ph.D., 1966.

OBJECTIVE — To provide officers through graduate education, with a comprehensive operational and technical understanding in the field of command, control and communications systems as applied to joint and combined military operations at the national and unified command levels. To develop individuals who have an understanding of the role C3 systems play in the use of military power; who have the ability to interpret the impact of C3 on operating philosophy; who possess an adequate background knowledge in basic technology and human capabilities and how these impact on current C3 systems, and who can perform requirement and planning studies of new C3 systems. These Officers should be able to undertake a wide range of assignments in C3 (both joint and intra-service) over the full span of a career.

Graduate will be expected to:

— Apply operational experience and analytical methods in specification and evaluation of C3 systems.

— Identify and articulate joint C3 requirements.

— Develop joint C3 systems plans, operating concepts, policy and requirements.

— Manage C3 systems operations, including the application of ADP software management and communications electronics.

— Adapt C3 systems design and operations to counter electronic and physical vulnerabilities.

QUALIFICATIONS FOR ADMISSION — The C3 Curriculum is open to all U.S. Military Services and selected civilian employees of the U.S. federal government. Students are normally at the O-3 and O-4 grade level. Admission requires a baccalaureate degree with C+ grades, and mathematics through differential calculus. A Top Secret security clearance is required with Special Intelligence (SI) clearance obtainable. Classes convene annually, in October. The program is typically six quarters in duration.

DESCRIPTION — The Command, Control and Communications Curriculum is multidisciplinary in nature, consisting of course work in operations research, computer science, administrative science, electrical engineering, mathematics and national security affairs. A major goal of the curriculum is to provide the student enhanced capabilities to operate effectively in such diverse areas as military decision making, current and future C3 systems design, and joint military operations. The curriculum is tailored to the requirements of selected officers who have outstanding performance records and anticipate continued careers focused on the conduct of military operations.

TYPICAL PROGRAM

INTRODUCTORY STUDY — This portion of the program is preparatory in nature, and portions of it may be validated by a student with appropriate operations and academic experience. The introductory courses include the following:

Probability
Fundamentals of structured programming
Mathematics for C3
Decision and data analysis
Information systems for C3
Introduction to signals and noise

GRADUATE STUDY — The graduate level courses of the curriculum include:

C3 mission and organization
Man/machine interaction
Simulation and war gaming
National intelligence systems and products
Computer graphics
Signals and noise
Analytical planning methodology
C3 exercise laboratory
Data base systems
Electronic warfare & C3 systems
Requirements determination
Telecommunication networks
Project management
C3 policies & problems
Elective

THESIS — Twelve quarter hours are allocated for thesis research in the final two quarters.

SEMINARS — Integral to the program is a schedule of C3 related seminars with key military officers and civilians knowledgeable in command, control and communications.

FIELD TRIP — An orientation tour of major C3 facilities is conducted to allow the student to become familiar with existing C3 operations and associated problems.

DEGREE — Successful completion of the program leads to award of the degree of Master of Science in Systems Technology (C3).

COMPUTER TECHNOLOGY PROGRAMS CURRICULA NUMBERS 367 AND 368

John Jacob Pfeiffer, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1963; M.B.A., National Univ., 1980.

Norman Floyd Schneidewind, Professor of Information Science and Computer Science; Academic Associate (Computer Systems); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (Engr), 1970; D.B.A., 1966.

Uno Robert Kodres, Associate Professor of Computer Science; Academic Associate (Computer Science); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

Bruce Robert Johnsen, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., South Dakota School of Mines, 1959; M.S. in Computer Systems Management, Naval Postgraduate School, 1974.

COMPUTER SYSTEMS CURRICULUM NUMBER 367

OBJECTIVES — This program is designed to:

— Provide the officer with the knowledge, skills, and practical understanding to evaluate changes and advances in the management of computers in the Military Services.

— Educate the officer in the technical aspects of computers and computer systems so that, in consonance with his management skills, he can effectively manage the implementation and proper utilization of computer based systems in military operations.

— Educate the officer in the fundamentals of systems development so that he is capable of translating operational requirements into systems specifications.

— Educate the officer in the concepts of economic analysis of computers in order to optimize costs and benefits.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree or the equivalent with above average grades in mathematics is required. Completion of differential and integral calculus and a course in psychology is considered minimal preparation. Students lacking these quantitative prerequisites may be acceptable for the program providing their undergraduate records and/or other indicators of success such as: GRE (Graduate Record Examination) GMAT (Graduate Management Admission Test) formerly ATGSB (Admission Test for Graduate Schools of Business), indicate a capability for graduate level work.

DESCRIPTION — The Computer Systems curriculum is an interdisciplinary program which integrates mathematics, accounting, economics, computer science, behavioral science, and management disciplines to prepare the officer to manage large computer centers, networks and systems. Program flexibility is available to permit a student to pursue, in depth, a specialization in an area of interest to himself and his service community. Completion of the computer systems program requires five quarters (1¼ years) or less depending on the student's academic background, experience and ability. Requirements for the Master of Science in Information Systems are met as an included part of the curricular program. In addition, Naval officers will be awarded the appropriate subspecialty code upon successful completion of the program.

Normal input for the Computer Systems curriculum is in October and March; however, on a case basis, students may commence their program in January or July through prior preparation and careful coordination with the Curricular Office.

INTRODUCTORY STUDY — This portion of the curriculum is generally preparatory in nature and some portions of it may be validated by the officer with appropriate experience or academic background. Undergraduate courses in the following areas are offered:

Introduction to computer management
Fundamentals of computer science

GRADUATE STUDY — The graduate portion of the program includes core courses in the following areas:

Probability and statistics
Operations research
Financial management
Economics
Economic evaluation of computer systems
ADP systems acquisition
Computing devices and systems
Software development
Operating systems
System analysis and design
Computer management
Organization and management

In addition to the graduate core, students select one of the option areas listed below or may propose an alternate area. The graduate courses shown under each option area are representative of the content of the areas. However, the students may choose electives from many other courses which are available in each area.

Computer Center and Network Operations
  Computer center operations
  Production management
  Survey of contemporary computer systems
Tactical Systems
  Digital machines
  Microcomputers
  Software engineering
Management Planning and Control
  Computer-based management information systems
  Internal control and auditing
  Data base system design
Information and Teleprocessing Systems and Networks
  Telecommunication systems, industry, regulations

Computer communications and networks
Man-Machine interaction

PROJECT/THESIS RESEARCH — Eight quarter hours are allocated for research, four in each of the student's final two quarters. Emphasis is on a group project or individual thesis derived from a military application in the field of computer systems management. The topic will be appropriate to the emphasis area selected.

COMPUTER SCIENCE CURRICULUM NUMBER 368

OBJECTIVE — This program is designed to:

— Provide an officer with the knowledge and skills necessary to specify, evaluate, and manage the design of computer systems.

— Provide technical guidance in applications ranging from basic data processing to sophisticated tactical systems.

— Educate the officer in the analysis and design methodologies appropriate to an understanding of the hardware and software components of complex computer systems.

— Provide the officer with the capability to utilize the modern computer laboratory in the application of computer techniques to research current military problems.

QUALIFICATIONS FOR ADMISSION — A baccaluareate degree or the equivalent with above average grades in mathematics is required. Completion of differential and integral calculus is considered minimal preparation. Undergraduate majors in applied science or engineering are highly desireable. Students lacking these prerequisites may be acceptable for the program providing their undergraduate records and/or other indicators of success, such as the Graduate Record Examination, indicate a capability to work in quantitative subjects. Documented practical experience in the computer field will also enhance a candidate's potential for admission.

DESCRIPTION — Computer Science is concerned with the representation, storage and manipulation of data by techniques and devices applicable to a wide variety of problems. This curriculum is an interdisciplinary program combining a core of software and hardware theory and applications with studies in mathematics, probability, statistics, operations research and electronics. Completion of the Computer Science program requires seven academic quarters (1¾ years) or less, depending on the student's academic background, experience and ability. Requirements for the Master of Science are satisfied as part of the curricular programs. In addition, Naval Officers will be awarded the appropriate subspecialty code upon successful completion of the program.

Normal input for the Computer Science curriculum is in October and March; however, on an individual case basis students may commence their program in January and July through prior preparation and careful coordination with the curricular office.

INTRODUCTORY STUDY — This portion of the curriculum is generally preparatory in nature and some portions of it may be validated by the officer with appropriate experience or academic background. Undergraduate courses in the following areas are offered:

Finite mathematics
Introduction to computers and programming
Fortran and Cobol programming
Digital machines

GRADUATE STUDY — The graduate portion of the program includes courses in the following areas: Representative areas of study are shown:

Applied probability and statistics
Discrete mathematics
Automata, formal languages and computability

- Structural programming languages
- Data structures
- Compiler design
- Operating systems
- Microcomputers
- Computer architecture
- Artificial intelligence
- Operations research
- Numerical analysis
- System design and analysis
- Management and electronics electives

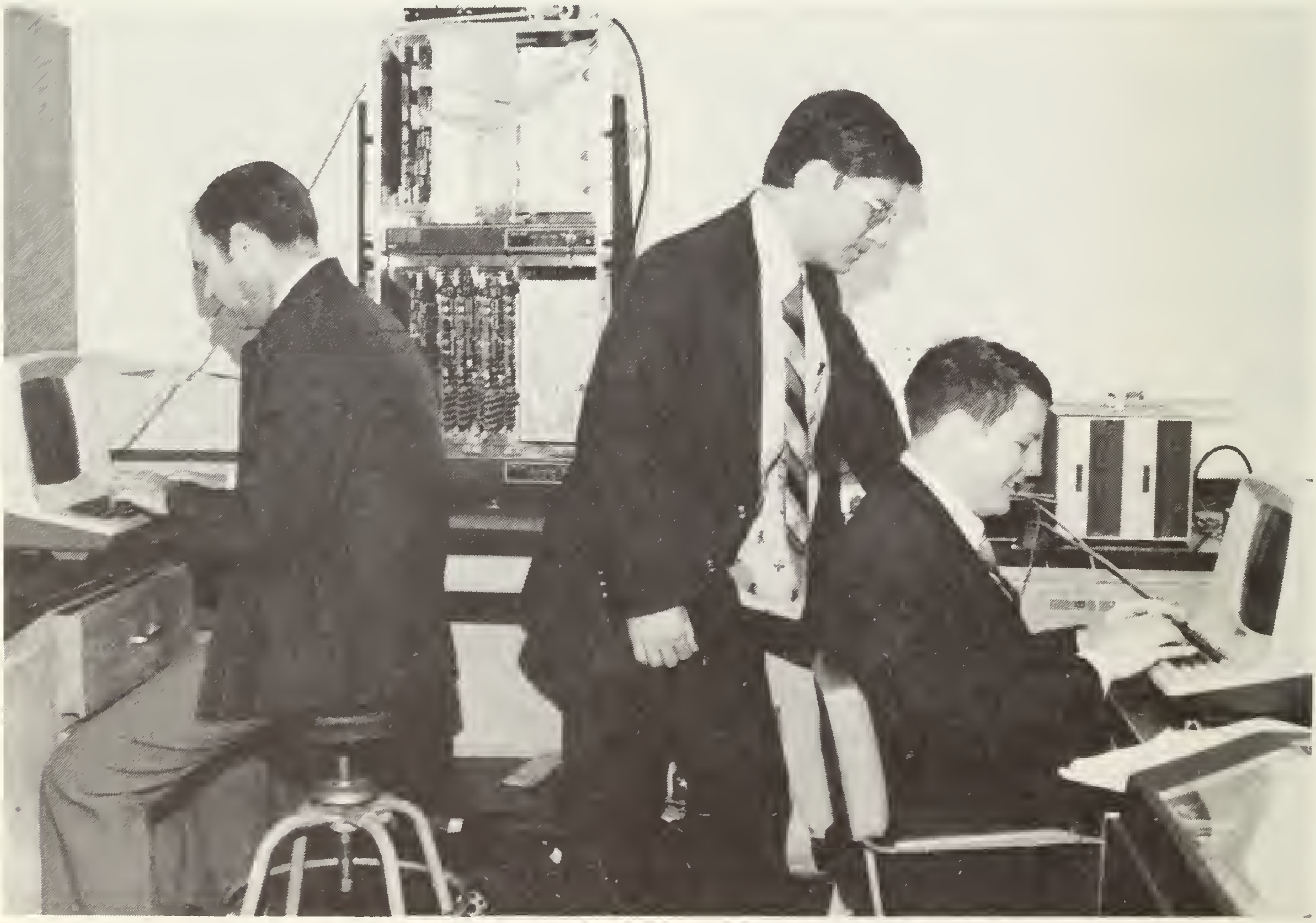
In addition to the graduate courses, one of the following three option areas must be elected:

TACTICAL COMPUTER SYSTEMS
- Advanced operating systems
- Computers in combat systems
- Software engineering
- Distributed computing
- System simulation
- Electronics engineering electives

COMPUTER SOFTWARE
- Advanced programming languages
- Advanced operating systems
- Software engineering
- Data base systems
- Interactive computation systems

MILITARY DATA PROCESSING
- Computer center operations
- Data processing management
- Data base systems
- Computer communications and networks
- ADP acquisition

THESIS RESEARCH — Sixteen quarter hours are allocated for thesis research, spread over the final three quarters of the student's program. Emphasis is on military applications and research in the computer science field. The thesis subject will be appropriate to the option area selected.



Students utilizing microcomputer equipment

ELECTRONICS AND COMMUNICATIONS PROGRAMS
CURRICULA NUMBERS
590, 595, 600, 620/620CG

Robert Alexander Persell, Jr., Commander, U.S. Navy; Curricular Officer; B.A., Univ. of Virginia, 1961; M.S. in International Affairs, George Washington Univ., 1971; M.S. in Management, Naval Postgraduate School, 1975.

Robert Denney Strum, Professor of Electrical Engineering; Academic Associate (Electronics/Communications Engineering); B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

Alan Wayne McMasters, Associate Professor of Operations Research and Administrative Sciences; Academic Associate (Telecommunications Systems); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

Alfred William Madison Cooper, Professor of Physics; Academic Associate (Electronic Warfare Systems Technology); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., Queen's Univ. of Belfast, 1961.

OBJECTIVE — The Electronics and Communications Programs include curricula designed to satisfy the needs of the service and the interests of the officers in these fields. Successful completion of a curriculum leads to the award of the degree of Master of Science or a higher degree in the principal field. This education permits the officer to address more knowledgeably current and future military problems associated with electronic/communications systems, and expands his base of professional knowledge and technical competence in his subspecialty area. It is designed to enhance performance in all duties throughout a naval career includ-

ing operational billets, technical management assignments, and the policy making positions.

Within the broad fields of electronics and communications, various option tracks are available after completing the graduate core requirements. Successful completion of the Engineering Electronics or Communications Engineering Curricula leads to an appropriate Navy subspecialty code, and each curriculum includes all requirements for the degree Master of Science in Electrical Engineering. The Electronic Warfare Systems Technology Curriculum results in an Electronic Warfare subspecialty code, and meets requirements for the degree Master of Science in Systems Technology. In the Telecommunications Systems Curriculum, the Communications Systems Technology Subspecialty code is earned, and the requirements for the degree Master of Science in Telecommunications Systems Management are met. All curricula provide the officer with a well-rounded knowledge of the scientific principles, technical practices and managerial/analytical skills pertinent to his field of study. The officer's studies also serve to produce a heightened capacity for creative thought and innovative problem solving. The curricula provide latitude for studies in associated areas outside the field of specialization to accommodate the academic background and individual interests of the officer and help him acquire diverse professional knowledge, a new appreciation for continuing education, an added awareness of the many complex elements of problems, and an enhanced personal confidence conducive to productive achievement throughout his naval career.

ENGINEERING ELECTRONICS CURRICULUM NUMBER 590

OBJECTIVE (SPECIFIC) — To educate officers in current electronics technology and its application to modern naval warfare.

COMMUNICATIONS ENGINEERING CURRICULUM NUMBER 600

OBJECTIVE (SPECIFIC) — To provide officers, through graduate education, with a comprehensive scientific and technical knowledge in the field of communications engineering as applied to Navy and Defense Command, Control and Communication Systems.

ENGINEERING ELECTRONICS AND COMMUNICATIONS ENGINEERING CURRICULA NUMBERS 590 AND 600

QUALIFICATIONS FOR ADMISSION — Prior baccalaureate degree including above average grades in differential/integral calculus and general physics. Those lacking in this background may matriculate via the Engineering Science program, or may upgrade their educational opportunities by taking courses off campus through the Continuing Education Program.

Allied officers may enroll in the above curricula subject to exclusion of classified courses as determined by the Chief of Naval Operations.

DESCRIPTION — These curricula are designed to establish a broad background of basic engineering knowledge leading to selected advanced studies in electronic systems, communications, electronic warfare, ship/weapon control systems, information processing or to other pertinent areas of professional applicability. Entry may be made in any quarter: October, January, March, or July.

The graduate portion of the program is normally of twelve months duration. It is preceded by an introductory core program which is designed to provide a smooth transition from previous studies and experience. For entering stutends who have a non-engineering background, except as stated in the qualifications above, and who have been absent from academic studies for five or more years, the background studies may be of up to five quarters duration, leading to a complete program duration of twenty-seven months. For students with better entrance qualifications, special review courses and course validations enable them to complete the total program in twenty-one or twenty-four months.

Toward the end of their preparatory program, officers are evaluated for academic progress and potential to complete the advanced degree portion of the curriculum. Academically superior students may be selected, subject to service needs and approval, for further advanced studies leading to the degree of Electrical Engineer, Doctor of Engineering or Doctor of Philosophy.

INTRODUCTORY CORE

The structure of each curriculum recognizes that the typical officer student has been away from an academic environment for some time and is not usually prepared to engage in graduate studies without some preparation. The core provides a sound academic background in mathematics, computer science and technology, physics and electrical engineering. Each student's prior academic transcript will be evaluated for validation of as many of these courses as possible, or for selection of an accelerated review course to replace a longer sequence of courses. Validation permits study of greater breadth or depth in graduate studies and can reduce the time on board required to fulfill subspecialty code and degree requirements. The courses which are not validated will be programmed using a nominal course load for 16-18 credit hours per quarter.

Subjects covered in the core courses include:

Calculus
Linear algebra
Differential equations
Complex variables
Numerical methods
Physics
Circuit theory
Control theory
Electronics engineering fundamentals
Linear and communications ICs
Computer programming
Digital machines and logic design
Electromagnetic wave theory and engineering
Communication theory
Applied probability
Vector Analysis

GRADUATE STUDY

The advanced studies program leading to a master's degree is invididually designed to be academically sound, consistent with the needs of the service and responsive to the interests and objectives of the officer. The program consists of courses in required subject areas, elective courses in coherent and relevant option areas and thesis research. Classroom work is supplemented by an active seminar series in which military and industrial leaders provide an operationally relevant perspective on current topics of interest. The degree requirements include completion of the requirements for the degree Bachelor of Science in Electrical Engineering and completion of 40 credit hours of approved graduate study. The additional thesis research normally occupies the time equivalent for four courses, allocated during the final three quarters of the program. Any transfer of graduate credit which is applicable will allow an opportunity in an officer's program for additional electives.

The Graduate Core

To provide a well rounded graduate program, all students are required to include courses in the subject areas of digital signal processing analysis of random signals, radiation, scattering and propagation, and microprocessor-based system design.

Options

The graduate program also requires a cohesive sequence in one of the selected areas listed below. Latitude is permitted in specific elective selections, with the choices being approved consistent with overall professional applicability and soundness of academic requirements.

Communications systems
Guidance, navigation and control systems
Radar, electro-optic and electronic warfare systems
Tactical digital systems

Upon successful completion of an approved curriculum, officers will be awarded an appropriate subspecialty billet code. On-going counseling is provided by the Curricular Officer/Academic Associate team for all officer students, and a close professional relationship between officer students and faculty enhances professional and career development.

ELECTRICAL ENGINEER

As determined by service needs and superior academic achievement, officers may matriculate into a program leading to the degree Electrical Engineer. This advanced graduate program requires approximately seven quarters of work beyond the introductory core. The scope of study is greatly increased over the Master of Science curriculum and a thesis of greater depth is required.

ELECTRONIC WARFARE SYSTEMS TECHNOLOGY CURRICULUM NUMBER 595

OBJECTIVE (SPECIFIC) — To provide the service with sufficient officers thoroughly knowledgeable in the technical and operational aspects of both the art and the role of Electronic Warfare as a vital, integral part of modern warfare.

QUALIFICATIONS FOR ADMISSION — This curriculum is open only to officers of the U.S. Armed Forces and selected civilian employees of the U.S. federal government. Admission to the curriculum requires a baccalaureate deree with above average grades. Completion of mathematics through differential and integral calculus is required. Students lacking this background may matriculate via the Engineering Science Program. Although designed primarily for unrestricted line officers with established warfare qualifications quotas may be available on a case basis for officers of the restricted line communities. Of equal importance to academic qualifications is demonstrated outstanding performance in an officer's warfare specialty. A tour of duty providing operational electronic warfare experience is also desirable but not mandatory. Officers selected for the 595 Curriculum must be eligible for security clearance permitting access to sensitive intelligence information.

DESCRIPTION — This curriculum is designed to provide an understanding of the principles underlying the broad field of electronic warfare. Because of the electronic nature of modern sensor, weapon and command, control and communication systems, this curriculum seeks to develop in the officer a grasp of electronic, electrical and electromagnetic fundamentals, theory and techniques. Another principal goal of the 595 Curriculum is to develop an ability to describe technological factors in terms which are meaningful and supportive in an operational tactical situation. To achieve these aims, preparatory material in mathematics, operations research, probability, statistics, physics and computer science are included in the program.

The 595 Curriculum is highly interdisciplinary and comprises several tracks. Inputs will occur annually in October. Each officer's transcript of prior baccalaureate study is evaluated to eliminate unnecessary duplication of previously covered material.

INTRODUCTORY CORE

This portion of the program provides a sound academic background in mathematics, computer science and technology, physics and electrical engineering. Each student's prior academic transcripts will be evaluated for validation of as many of these courses as possible. The courses which are not validated will be programmed using a nominal course load of 16-18 credit hours per quarter.

Subjects covered in the core courses include:

Calculus and vector calculus
Ordinary differential equations and Laplace transforms
Fourier analysis and partial differential equations
Probability theory
Physics
Electro-optics fundamentals
Computer programming
Real time combat direction systems
Electronic systems
Signals and noise
Pulse and digital circuits
Control systems
Electromagnetic theory
Decision analysis and data analysis
Simulation and war gaming
Meteorology

GRADUATE STUDY

The operational Electronic Warfare Curriculum qualifies the student for the degree Master of Science in Systems Technology. During the last three quarters of this eight-quarter (two-year) program the officer undertakes thesis research and preparation on a topic relevant to current military electronic warfare efforts. A program of seminars given by representatives of EW-oriented activities and industry supplements classroom instruction. Subjects covered include:

Microwave devices and radar
Signal processing systems
Electromagnetic radiation, scattering and propagation
Electronic warfare systems
Electro-optics
Human factors for EW
Operations analysis
Operational test and evaluation
EW computer applications
SIGINT and threat environment
Underwater sound, systems and countermeasures
Communications in organizations
Naval warfare and national security

TELECOMMUNICATIONS SYSTEMS MANAGEMENT CURRICULA NUMBERS 620 AND 620CG

OBJECTIVE (SPECIFIC) — To provide instruction to officers who will perform as Communications Managers of new communications systems applications or as Communication Officers in large commands and staffs, afloat and ashore, including the organization of the Joint Chiefs of Staff and the Defense Communications Agency.

QUALIFICATIONS FOR ADMISSION — Admission to the curricula requires a baccalaureate degree with above average grades. Completion of mathematics through college algebra and trigonometry is required for the 620 curriculum. The qualifications for the 620CG curriculum are the same as the 590 and 600 curricula. The student must be ready to start calculus courses on enrollment.

DESCRIPTION — The 620 and 620CG curricula are sponsored respectively by the Director, Naval Communications and U.S. Coast Guard Headquarters. Each curriculum provides comprehensive study in management, with emphasis upon the systems management field. Additionally, the curricula provide study in the technical field appropriate to decision making in advanced systems and program management. These technical courses within the 620 curriculum have been especially prepared for non-engineers whereas those in the 620CG curriculum are engineering courses. Classroom instruction is supplemented by guest lecturer seminars which afford the student an opportunity to hear discussions of communications topics by military officers and civilian executives from the Naval Telecommunications Command, Defense Communications Agency, National Security Agency and other major communication activities.

The 620 classes convene in October. Officers whose undergraduate transcripts indicate a strong background in mathematics through calculus may, on a case basis, enter a quarter early, in July, or a quarter late, in January. Students are accepted for the 620CG curriculum in either October or March. Each student's prior academic transcript is evaluated for validation of courses or for transfer of credit to cover as many courses as possible. Validation is also encouraged for courses whose content has been acquired by experience or service courses. The curricula are interdisciplinary in nature because of the wide knowledge required of the graduate. Each curriculum consists of a number of basic courses designed to provide a smooth transition from previous studies. It is required that each student follow a program of graduate level study which will yield 40 credit hours in Administrative Sciences and Quantitative Methods and 16 credit hours in Communications Systems and Computer Science. Successful completion of the program leads to the degree Master of Science in Telecommunications Systems Management. Representative course titles for the core are listed below:

620 (Navy) Curriculum

Calculus and matrix algebra
Probability and statistics
Operations research
Electronics systems
Communications systems
Signal transmission systems
Communications systems analysis
Financial and managerial accounting
Managerial economics
Defense resource allocation
Economics of communications systems
Individual and group behavior
Organizational theory
Procurement and contract administration
C3 mission and organization
Personnel management and labor relations
Naval telecommunications and management
Computer programming
Real time interactive computer systems
Real time information systems management

620CG (Coast Guard) Curriculum

Calculus and matrix algebra
Differential equations
Complex variables
Applied probability theory
Operations research
Linear programming
Networks flows and graphs
Basic circuit theory
Circuit theory
Electronics fundamentals
Communications theory
Electromagnetic theory
Digital communications
Electromagnetic radiation and compatibility
Statistical and communication theory
Financial and managerial accounting
Managerial economics
Defense resource allocation
Individual and group behavior
Organization and management
Procurement and contract administration
Computer programming
Structure of digital computers
Real time interactive computer systems
Real time information system management
Computer based management information systems
Leadership and group behavior
Management policy
Procurement policy
Internal audit and control
Economics of computers
Communications satellite systems engineering

Spanagel Hall

ENGINEERING SCIENCE PROGRAM

OBJECTIVE — To provide officers who desire and are selected for an advanced technical education, but who are deficient in mathematics and the physical sciences, an opportunity to qualify for admission into one of the graduate level technical programs at Naval Postgraduate School.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with a C+ average, completion of at least two pre calculus mathematics courses with a B average, or at least one course in calculus with a C grade and at least one course in physics.

DESCRIPTION — Officers ordered to this preparatory program are assigned to the curricular office of the graduate curriculum they have been selected to attend. Each officer selects courses to correct his personal deficiencies, concentrating on basic mathematics, physical science and courses in the preparatory part of his graduate curriculum.

Normal input to the curriculum occurs in March and October, with a planned duration of two quarters. Inputs can be accepted at other dates dependent on the starting dates for the graduate curriculum to be followed.

NATIONAL SECURITY AFFAIRS/INTELLIGENCE PROGRAMS

CURRICULA NUMBERS 681, 682, 683, 684, 686, 687, AND 825

Richard John Schlaff, Captain, U.S. Navy; Curricular Officer, B.A., Michigan State Univ., 1959; M.B.A., Univ. of Denver, 1965.

Eddy Louise Sorek, Lieutenant, U.S. Navy; Special Security Officer, Programs ADP Officer; B.S., Purdue Univ., 1974; M.A., Central Michigan Univ., 1977.

John Joseph Kearney, Lieutenant, U.S. Navy; Assistant Curricular Officer (National Security Affairs and Intelligence); Assistant Special Security Officer; B.S., U.S. Naval Academy, 1977.

William Reese, Professor of Physics and Defense Technology; Academic Associate (Intelligence); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

Edward John Laurance, Associate Professor of Political Science; Academic Associate (National Security Affairs); B.S., U.S. Military Academy, 1960; M.A., Temple Univ., 1970; Ph.D., Univ. of Pennsylvania, 1973.

NATIONAL SECURITY AFFAIRS NUMBERS 681, 682, 683, 684 686 AND 687

OBJECTIVE — These curricula are designed to provide graduate education to officers and civilian employees of the U.S. Government emphasizing: politico-military affairs, strategic and operational planning, attache affairs, intelligence and area analysis. These curricula include specialty programs (681, 682 and 683 — delivered in cooperation with the Defense Language Institute (DLI), also in Monterey) and functional specialty programs (684, 686 and 687) conducted entirely at the Postgraduate School. Completion of any of these curricula leads to the degree of Master of Arts in National Security Affairs.

Specific educational objectives related to these curricula are:

(1) Geopolitics — Students will be familiar with the geopolitical regions of the world in terms of their global strategic importance. They will understand how geography, climate, economics, and demography influence political thought and foreign policy.

(2) Strategic Posture — Students will know the national strengths and weaknesses which affect strategic posture and capabilities. They should be able to assess major military, political, economic, and sociological trends as they relate to policy choices in domestic and foreign affairs.

(3) Military Forces — Students will understand the role, political influence, social position, composition, structure, capabilities, and vulnerabilities of the armed forces. They should be familiar with current political and military developments, regional military and political relations, and regional defense agreements.

(4) Geography — Students will have knowledge of geography and its influence on national development, domestic transportation, economic and military posture. Area specialists should have a more detailed geographical knowledge of their areas and appreciate the strategic significance of their specific regions.

(5) Economics — Students will be aware of the economic strengths and weaknesses of the major power blocs of the world, as well as economic phenomena which influence ideology, military doctrine, industrial and social development. Area specialists must be familiar with their respective region's principal resources and economic influence in the world, as well as its industrial capacity.

(6) Politics — Students will have a knowledge of the major types of political systems and governmental organizations. They should be aware of current political doctrine and issues. They should know the strength, appeal and influence of Communism and other ideologies. Area specialists should have a more detailed knowledge of their area and be aware of the current relationships and attitudes toward both the United States and the Soviet Union prevalent in it.

(7) Historical Development — Students should understand the historical trends and influences that have shaped and provide the context for interaction in today's international environment and future developments. Area specialists should acquire detailed knowledge concerning historical developments in the region of their specialty, with particular emphasis on political evolution, traditional enemies and conflicts, regional alliances and domestic issues.

(8) Culture and Religion — Students will be familiar with the influence of class structure, cultural and religious values, and ideology on domestic and foreign affairs. They should understand the origins and present status of cultural and religious differences and conflicts, and how these differences affect regional and national cohesiveness.

(9) Current Issues — Students will be familiar with the major security issues in the world today. These include, but are not limited to, political and military conflicts, insurgencies, social problems and efforts for social reform, economic problems and other issues which affect both the status or well-being of the nations of the world. Knowledge of these issues should be related to the formulation and implementation of U.S. foreign and security policy.

(10) Analytical and Research Skills — Scholarly skills emphasized throughout the program include: effective oral and written expression, techniques of research, interpretation and evaluation of complex data, problem solving, forecasting, decision making, the process of negotiation and debate, the formulation of strategy and politico-military objectives.

(11) Language — Area specialists should be capable of maintaining their

expertise by continuing study in their professional area. This would include the reading of newspapers and journals written in the language of the area in order to be cognizant of developments. The ideal area specialist should have intensive language training in one major language group and acquire working knowledge of a second language in this specialty area.

QUALIFICATIONS FOR ADMISSION — Officers and civilian employees of U.S. federal government. The entrance requirements for these programs are a baccalaureate degree earned with above average academic performance. Applicants may demonstrate their aptitude for the specific curriculum concerned through undergraduate courses that meet program prerequisites, Graduate Record Examination results, or other evidences. Applicants must have the approval of the Chairman, Department of National Security Affairs.

AREA SPECIALTY CURRICULA

#681 — Middle East, Africa, South Asia
#682 — Far East, Southeast Asia, Pacific
#683 — Europe, USSR

DESCRIPTION — These curricula are cooperative programs with the Defense Language Institute. They last from one to two years depending upon the curricula and option selected, the language studied, and previous educational background. Officers are assigned to NPS for the full duration of the combined program. Quotas for the language instruction are obtained directly from DLI by the Curricular Office, except in the case of those students who have acquired language proficiency either at DLI or other institutions prior to their admission to the program.

Student programs are individually tailored. Course selection depends upon an officer's academic and professional background, sponsor requirements, and area specialty concerned. Course mix and sequence will also vary according to the quarter of entry. Each of the three curricula is built upon a common core of approximately six courses.

Common Core

The common core provides a foundation for students in the methodological approaches to analysis of the international environment, major specific affairs issues applicable to all regions of the world, and the conduct of U.S. security affairs. Topics covered include the following:

Conceptual framework for understanding comparative politics
Theories of political development and change
Research design
Modeling factors of interstate behavior and national decision making
World trade and the international monetary system
Location and flow of strategic resources
Cross-national security assistance including arms and technology transfer
Defense decision making process
Executive/legislative interaction and influence
Perspectives on American civilization

#681 — Middle East, Africa, South Asia

Individual programs in this curriculum emphasize area studies focused on one of the three subregions in this program or contain a blend of courses applicable to all three subregions. Courses in the following areas are offered:

Impact of geographic and oceanographic environment on military campaigns
Communications, natural resources, and environmental factors — their impact on the African continent
Religious and social systems of Southern Asia
The Arabic, Judaic, Turkish and Persian traditions

- Interplay of political and social forces within the Middle East
- Internal African policies and their impact on U.S. security interests
- Soviet interests and naval expansion in the Indian Ocean
- The changing importance of Middle East oil in the world supply of energy
- Strategic problems of access to and defense of the Mediterranean littoral
- Strategic resources as determinants in great power involvement on the African continent

#682 — Far East, Southeast Asia, Pacific

Individual programs consists of a blend of courses applicable to all three of these subregions. Courses dealing with the Soviet Union, a Eurasian power and major actor throughout Asia, are included in all options. Courses in the following areas are offered:

- Historical forces relevant to modern revolutionary movements
- The great Asian religions and their role in the development of social systems
- The role of ethnic minorities and the influence of the overseas Chinese
- The transformation of Indo-China into communist states
- Present and future military capabilities and strategies of Asian states
- Nationalism, development and security in the governments of South Asia
- Crisis management and trends in Soviet foreign policy
- Forecasting international conflict in Asia
- The extent and influence of Sino-Soviet relations on other nations
- Elements of strategic geography: the political, economic, social and military applications

#683 — Europe, USSR

Individual programs emphasize area studies focused on these subregions. Courses in the following areas are offered:

- Nuclear proliferation, technology and politics
- Deterence theory and practice
- Elements of strategic geography: the political, economic, social and military applications
- The polarization of Europe into two security systems: NATO and the Warsaw Pact
- Domestic factors conditioning Soviet national security policy
- Doctrinal and functional analysis of Soviet naval strategy
- Patterns of communist takeovers and system development
- Strategic problems of access to and defense of the Mediterranean littoral
- Current issues in Soviet-European affairs

FUNCTIONAL SPECIALTY CURRICULA

#684 — International Organizations and Negotiations

This curriculum focuses on the security relationships between the United States and other nation states, their interests, and includes the organization and structure through which such relationships are conducted and the development of international institutions and policies that provide guidelines for such interaction; such as international law, the law of war and the law of the sea. Some continuing emphasis beyond core studies on U.S. national security affairs is also included. Courses in the following areas are offered:

- The legal reasoning and source materials employed in international law
- Case studies of international organizations: their utility and limitations
- American goals, objectives and resources applicable to international relationships
- Concepts and technical aspects of a rational ocean policy
- Utility and limitations of models used in the policy sciences for ana-

lyzing the defense policy process
Oceanographic, military, political, economic and legal problems of the oceans
Arms control and disarmament
Soviet political institutions and economic structures
Viewpoints of both oil exporting and oil importing countries
Alliances, bases and security systems in Asia

#686 — Strategic Planning - General
#687 — Strategic Planning - Nuclear

These curricula focus on major issues and U.S. security affairs with equal emphasis. The major thrust is the evolution of military capabilities, force employment and contingency situations. Courses in the following areas are offered:

Prerequisites for analysis of defense budgets
Pattern analysis of terrorist activities
Technological and political influences of nuclear weapons
Factors dominating the arms transfer policies of the major powers
Impact of arms transfers on regional conflict and economic development
Strategic context of American national security policy
The role of OMB, NSC, and the Presidential Staff
Forecasting the influence of technology on public policy
Access to critical raw materials and defense of trading routes
Threat analysis and net assessment
Arms competition, nuclear proliferation and terrorism
Systematic strategic resource analysis
The political, military and economic issues in Europe since 1945
Impact of oil revenues on Middle Eastern regional development and military balance
Crisis management and trends in Soviet foreign policy
Modeling Soviet and U.S. naval interaction
Western and Soviet interests in the Mediterranean and the policies of surrounding states

INTELLIGENCE CURRICULUM
#825

OBJECTIVES — Objectives of the curriculum are to provide the students with advanced education in the following areas:

(1) the security interests of the United States and other major countries with particular emphasis on the military, economic, political, and social factors which shape and affect their interests and capabilities;

(2) the vocabulary, resources, and basis of operation of military systems and subsystems which allow the incorporation of technical and environmental information into the solution of intelligence problems;

(3) an understanding of the strengths and weaknesses of current military systems (primarily NATO and the WARSAW PACT nations) and areas of probable improvement within the next 10 to 15 years;

(4) methods of analysis applicable to the intelligence process, with particular emphasis upon forecasting and threat assessment;

(5) problems in the administration and dissemination of intelligence information, and the management of the intelligence process;

(6) techniques of interpersonal and group communication.

QUALIFICATIONS FOR ADMISSION — Be a U.S. officer or a civilian employee of the U.S. federal government and have a baccalaureate degree with a B average and college algebra or its equivalent and demonstrated excellence in a warfare or restricted line specialty. Officers selected must be eligible for Special Intelligence access. Recipients of orders not having a current Special Background Investigation (SBI) (within four and one half years), must submit the required request forms exeditiously in accordance with their PCS orders.

DESCRIPTION — The Intelligence Curriculum is an interdisciplinary program which integrates politics, science, mathematics, management, operations

analysis, oceanography, meteorology, electrical engineering, physics, computer science and economics into an understanding of Intelligence.

Those students who can validate specific core courses are permitted to concentrate in greater depth in a certain area or to choose electives from other areas that will broaden their background. Two electives in the fifth and sixth quarters are allowed for all students. Many students select courses that relate directly to their thesis research effort to provide the opportunity for the further acquisition of skills, methodologies, and knowledge in this area. Each student's program must be aprroved by the Curricular Office.

An original research project resulting in an acceptable thesis is an integral part of the curriculum. Research efforts are directly supported by the intelligence community.

Students in the Intelligence Curriculum will, in general, pursue the following course sequences: (1) Defense Technology, (2) National Security Affairs, and (3) Analytical and Management.

The Defense Technology sequence is designed to address the special problems of technical intelligence, emphasizing technical literacy and the ability to communicate concerning technological and environmental problems. The sequence seeks to provide the perspective that will assist assessment of the reliability and significance of technical and environmental data, as well as ensure familiarity with the resources in these fields that may be applied to intelligence problems. New technological developments, weapons system acquisition, and technological forecasting are pursued through student participation in seminars and practical exercises. Sample topics contained in this sequence include the following:

- Environmental data networks
- Electromagnetic and acoustic wave propagation
- Acoustic surveillance concepts and systems
- Radar systems: observables and ELINT, capabilities and system options, components
- Optical systems: visual and infra-red
- Communications theory: spectral analysis, modems and systems
- Control systems: concepts and components
- SIGINT systems
- Strategic systems
- Technical threat analysis
- Technological forecasting
- Technological developments in C3 and intelligence

The National Security Affairs sequence delineates the interface between international politics, defense resource management and weapons technology. The courses in this sequence emphasize both American national security affairs and area studies. Sample topics include the following:

- Use of systems theory to explain international events and trends
- Foreign policy and crisis decision making
- Defense policy objectives and strategy
- U.S./Soviet net assessment
- Dynamics of Soviet decision making
- Soviet warfare capabilities

The Analytical and Management sequence introduces the student to quantitative techniques, substantive research methods, and the primary concepts of resource management. It provides a methodological survey of various means to structure given problems, formulate possible solutions, organize and compile the supporting data, assess the reliability and communicate the significance of the results obtained. Sample topics include the following:

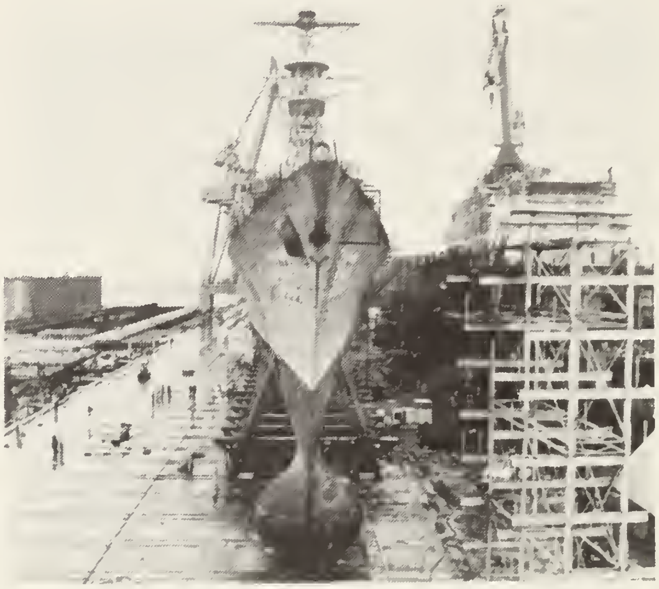
- Common transcendental functions
- Differential and integral calculus
- Probability and statistics
- Public personnel administration
- Public sector resource management
- Data base management systems
- Research design and measurement
- Content and events data analysis
- Decision analysis
- Project management
- Campaign analysis
- Quantitative assessment of military capabilities
- Intelligence measurement methods
- Methodological case studies
- Analysis of Soviet military operations

Students analyze Soviet naval exercises; the KARA above is a modern Soviet guided missile cruiser

NAVAL ENGINEERING PROGRAM CURRICULUM NUMBER 570

Grant Richard Garritson, Captain, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1961; Ph.D., Univ. of Notre Dame, 1968.

Matthew Dennis Kelleher, Associate Professor of Mechanical Engineering; Academic Associate; B.S., Univ. of Notre Dame, 1961; M.S.M.E., 1963; Ph.D., 1966



NAVAL ENGINEERING CURRICULUM NUMBER 570

OBJECTIVES — To provide graduate education, primarily in the field of Mechanical Engineering, to officers from all communities. The graduate will have the technical competence to operate and maintain modern warships and naval systems. He will be able to participate in technical aspects of naval systems acquisition and be able to recognize applications for technological advances in naval ships and systems. Through emphasis on the design aspect within the program, the graduate will be well prepared to apply these advances in technology to the warships of the future.

ENTRANCE DATES — March and October are best for effective program scheduling; however, classes convene any quarter.

QUALIFICATION FOR ADMISSION — A baccalaureate degree or its equivalent, preferably in engineering or the physical sciences, is required. Mathematics through integral calculus plus one year of physics are non-waiverable requirements. One year of chemistry at the college level is highly desirable but not mandatory. The Engineering Science program (Curriculum Number 460) is available for candidates who do not meet all admission requirements. The additional time required will vary with the candidate's background.

DESCRIPTION — The academic program is grouped into an introductory study portion and an advanced graduate level study portion. The introductory study program consists of undergraduate and graduate level courses which provide the necessary breadth and depth for successful pursuit of the advanced graduate level study portion of the program. Each student's transcript is evaluated for validation of as many of the introductory study courses as possible and the student is interviewed upon arrival to reach a final decision on those courses to be programmed for the introductory study program. This portion of the curriculum includes courses in the following areas:

Undergraduate Introductory Study

Calculus review
Linear algebra and vector analysis
Computer Programming
Ordinary and partial differential
  equations/complex functions
Engineering materials
Statics and dynamics
Mechanics of solids
Engineering thermodynamics
Fluid mechanics
Electrical engineering fundamentals

Graduate Introductory Study

Heat transfer
Advanced mechanics of solids
Mechanical vibrations
Marine power systems
Nuclear power systems
Intermediate fluid mechanics
Design of machine elements
Marine gas turbines
Engineering numerical analysis
Properties of structural materials
Probability and statistics

Advanced Graduate Study

After completion of the introductory study portion of the program, a coherent sequence of electives are selected from the advanced graduate level courses. These are chosen in consultation with the Curricular Officer and faculty advisors. A normal program of study leading to the degree Master of Science in Mechanical Engineering will allow for three such elective courses chosen from the following extensive list:

FLUID MECHANICS
  Viscous flow
  Fluid power control
  Naval hydrodynamics
  Advanced applied mechanics of
    naval and ocean structures

HEAT TRANSFER
  Applications of heat transfer
  Conduction and radiation
  Convection
  Advanced topics in fluid dynamics
    and heat transfer

MARINE ENGINEERING
  Marine propulsion control systems
  Marine vehicle design
  Marine engineering design

MATERIALS SCIENCE
  Corrosion in the marine environment
  Microscopy
  Phase transformation
  Advanced engineering materials
  Welding Processes

NUCLEAR ENGINEERING
  Nuclear reactor analysis
  Reactor engineering principles and
    design

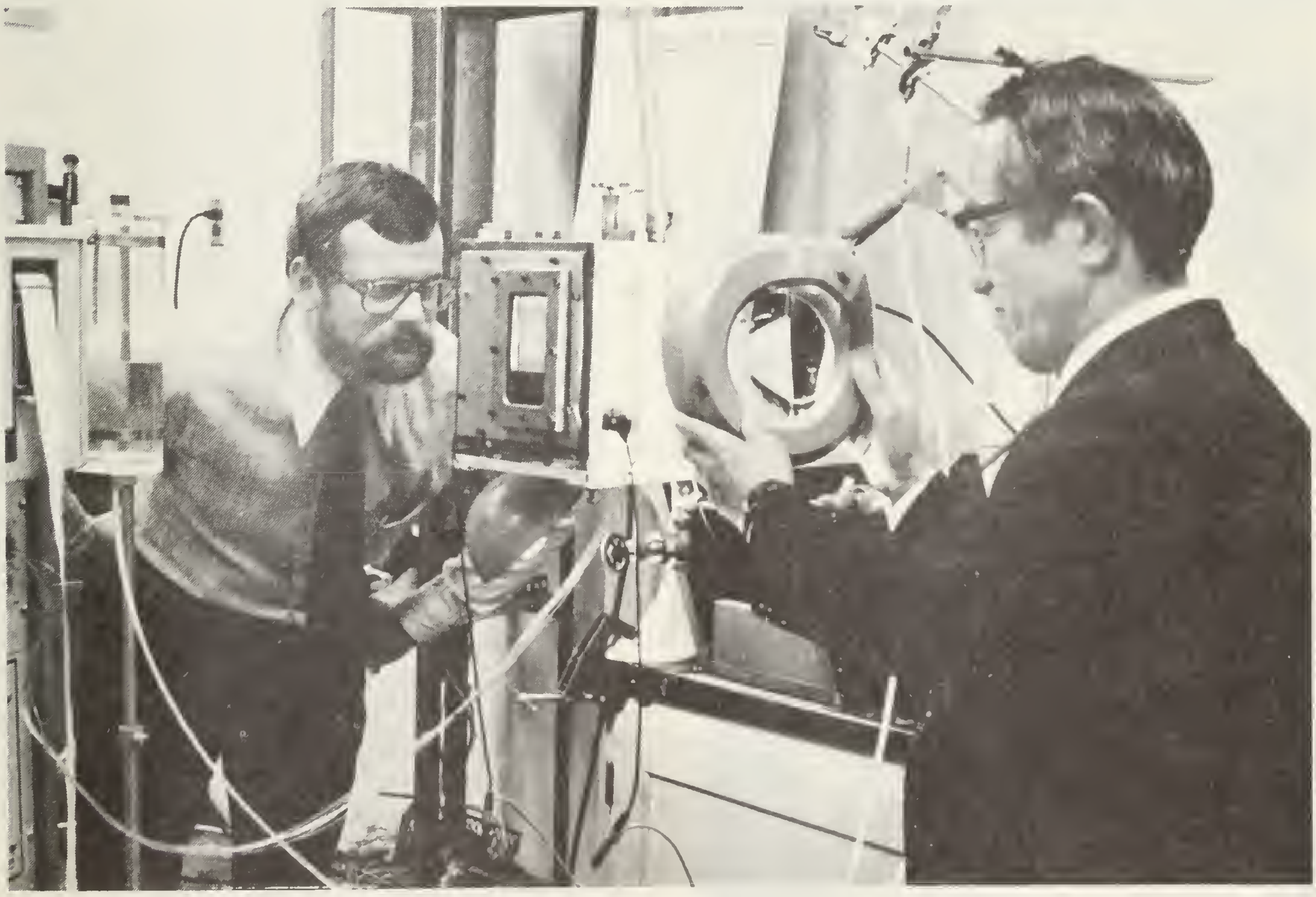
SOLID MECHANICS
  Advanced mechanics of solids
  Finite element methods
  Theory of continuous media
  Advanced vibrations
  Advanced dynamics
  Vibration, noise, and shock

Availability of a graduate course may be dependent on student loading at the time the course is desired. In special cases, an advanced topics program in the subject area of interest may be arranged between the professor and student.

THESIS — An original research project resulting in a finished thesis is an integral part of the curriculum. The schedule of classes is arranged to provide time during the final two quarters for concentration in this area of specialization. Topics are selected in the fifth quarter of the students program for approval by the Chairman, Department of Mechanical Engineering. A faculty advisor is assigned for consultation in designing and conducting a program of research. Considerable emphasis is placed on the production of a quality thesis.

ADVANCED DEGREES — The Naval Engineering program is designed to lead to the degree of Master of Science in Mechanical Engineering. A limited number of particularly well qualified students may be able to further their education beyond the master's level and seek the degree of Mechanical Engineer. Additional courses are chosen from the list of advanced graduate courses and a thesis of greater scope and depth is required. The additional time required to meet the requirements for the Mechanical Engineer degree will vary with the individual's progress at the time of entry into the advanced program. Criteria for selection include superior academic performance, tour availability, and a demonstrated capability to perform in the environment of the professional engineer. A program leading to the Doctor of Engineering or the Doctor of Philosophy degree can also be made available to the truly outstanding student who can qualify as a candidate for this most demanding course of study. The principle governing factor in the availability of a doctoral study opportunity is the requirement of the Navy to meet billet requirements at the time of application.

SUBSPECIALTY CODE — Those officers successfully completing these programs will be identified as subspecialists in accordance with the current instructions.



Student and Visiting Professor viewing compact boiler research apparatus

OPERATIONS ANALYSIS PROGRAMS
CURRICULUM NUMBER 360

Joel Ross Sartoris, Lieutenant Commander, U.S. Navy; Curricular Officer; B.S., Univ. of Mississippi, 1964; M.S., Naval Postgraduate School, 1973.

James Kern Hartman, Associate Professor of Operations Research, Academic Associate; B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

OPERATIONS ANALYSIS CURRICULUM NUMBER 360 (GROUP RO)

OBJECTIVE — To supply the Services' needs for a cadre of military operations analysts for assignment to Department of Defense headquarters staffs, other major staffs, development groups, operational staffs and various Defense Department agencies.

This program provides education in the application of quantitative analyses to operational, tactical, and managerial problems. The disciplines of mathematics, probability, statistics, economics, human factors, physical science, and optimization which the officer student learns here or brings with him, supply the theoretical background for analyzing alternative choices in tactical and strategic warfare and in planing, budgeting and procurement of systems and forces. The course of study generates computational capability and develops skills in identifying relevant information, generating decision criteria, and selecting alternatives. This education enhances performance in all duties throughout a military career, including operational billets, technical management assignments and policy making positions.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above average grades in mathematics is required. Completion of mathematics through calculus is considered minimal preparation. A one year course in college physics is highly desired (Supply Officers excluded). Students lacking these quantitative prerequisites will be accepted, in certain cases, where their under-graduate records indicate that they are exceptional students and there are other possible indicators of success such as Graduate Record Examination scores, correspondence or extension courses in quantitative subjects, and outstanding motivation for the program.

ENTRANCE DATES — March and October.

DURATION — Tailored to the student's qualifications; generally 1½ to 2 years.

DEGREE — Requirements for the degree Master of Science in Operations Research are met as an included part of the curricular program.

DESCRIPTION — The Operations Analysis programs are interdisciplinary in nature, consisting of two phases: an introductory phase of basic courses which are required as prerequisites for graduate level studies, and an advanced phase which permits the student to examine a selected area of analysis to some depth. The introductory phase is tailored to the individual's background and qualifications. This portion of the program is of variable length depending on the amount of course work listed below which can be validated by examination or credited from prior academic work. The length of the advanced phase is tailored to the curricular objectives and the requirements of the parent service or organization. A thesis is required in addition to the course work.

INTRODUCTORY STUDY

The introductory phase prepares students in the following disciplines:

Calculus
Linear algebra
Computer programming in FORTRAN
Applied physics (underwater acoustics, lasers, infra-red, radar, defense communications systems and weapons systems and effects)
Probability and statistics
Mathematical economics and resource allocation
Linear programming
System simulation
Human factors in systems design

GRADUATE STUDY

Core Courses

The advanced phase commences with required courses in the following disciplines:

Systems Analysis
Combat models and war gaming
Stochastic models
Interactive computer techniques
Data analysis
Nonlinear and dynamic programming
Search theory and detection (USN Line)

EXPERIENCE TOUR — During the early part of the advanced phase the U.S. student is assigned a six-week experience tour with Department of Defense analysts and other groups engaged in analyses of military problems. International students are assigned experience tours consistent with classification considerations and their country's desires and at no cost to the U.S. government. Some agencies which have participated in the experience tour program in the past include:

Office of the Chief of Naval Operations
Office of the Secretary of Defense
Joint Chiefs of Staff
Center for Naval Analyses
Naval Safety Center
U.S. Army Concepts Analysis Agency
Marine Corps Tactical Systems Support Activity

Naval Systems Commands
Supreme Allied Commander, Atlantic (SACLANT)
Operational Test and Evaluation Force
Naval Electronics Laboratories
U.S. Army Combined Arms Development Activity
Institute for Defense Analysis
U.S. Arms Control and Disarmament Agency
Navy Recruiting Command
U.S. Army Operational Test and Evaluation Agency
Experimental Squadron FIVE
State Department
Destroyer Development Group
Submarine Development Group
Project Managers under the Chief of Naval Material

THESIS RESEARCH — A thesis is required in addition to the course work. A total of 8 quarter hours are allocated for thesis research during the last half of the student's program.

ELECTIVE COURSES — At the completion of the experience tour the student may choose electives from course sequences which offer specialization in a particular area in recognition of requirements of the officer's military service or corps, as well as his background and interests:

Operations Evaluation (Navy) — Preparation for dealing with the analysis of tactics and hardware in Naval warfare. Courses include:

Search theory and detection
Operations research problems in naval warfare
Tactical design and analysis
Skilled operator performance
Test and evaluation
Sound in the ocean
Reliability and weapons system effectiveness
Campaign analysis
Applications of search, detection and localization models to ASW

Operations Evaluation (Marine Corps, Army) — Preparation for dealing with the analysis of land combat operations. Courses include:

Army operations research
Land combat models
Combat analysis
Test and evaluation
Games of strategy
Campaign analysis
Design of experiments
Reliability and weapons system effectiveness

Systems Analysis — Preparation for dealing with defense department resource allocation, planning, and programming. Courses include:

Theory of systems analysis
Econometrics
Defense expenditure and policy analysis
Cost estimation
Campaign analysis
Defense systems acquisition

Human Factors — Preparation for dealing with human performance evaluation and the design of man/machine systems. Courses include:

Skilled operator performance
Operations research in military man/machine systems
Evaluation of human factors data
Human performance evaluation
Human factors in systems design
Design of experiments

Logistics — Preparation for dealing with supply systems for Navy Supply Corps and Quartermaster or Maintenance officers. Courses include:

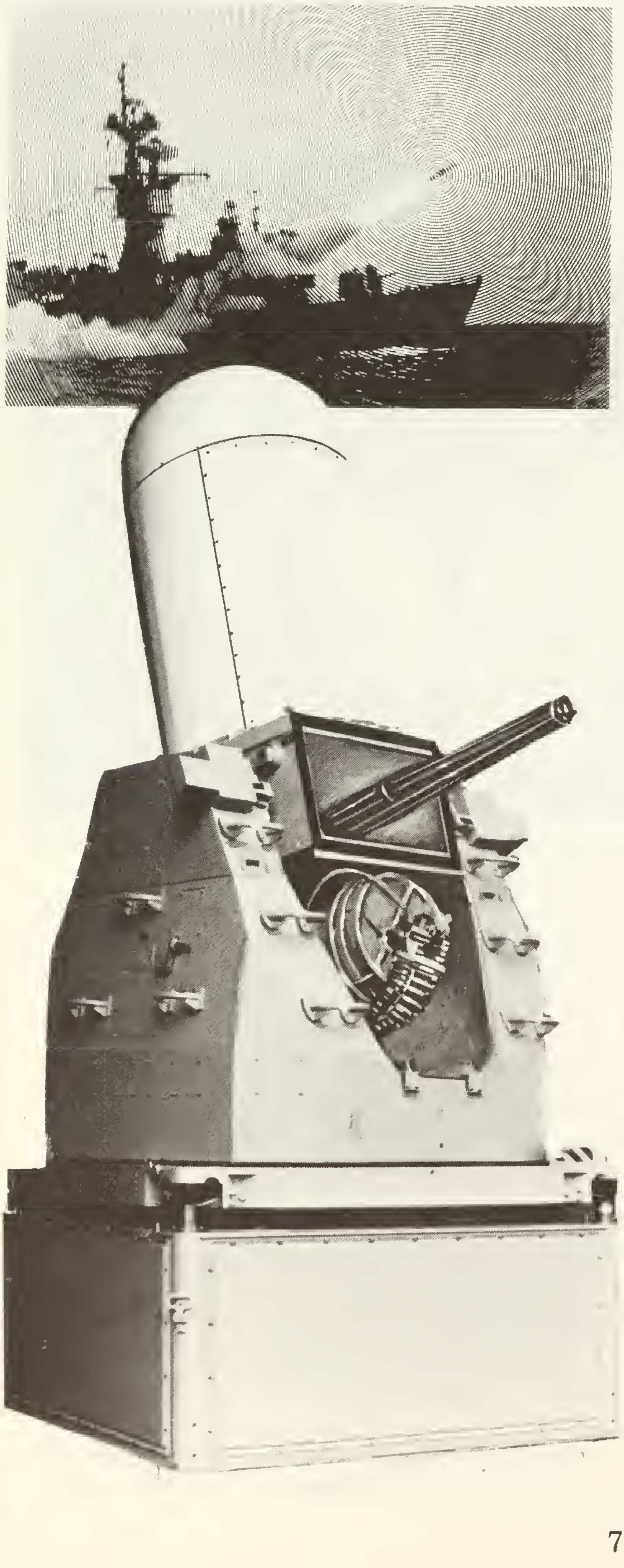
Inventory theory
Military supply systems
Financial and managerial accounting
Time series analysis
Military procurement and contract administration
Military application of management information systems
Physical distribution in supply systems
Logistics engineering

Advanced Modeling — Preparation for dealing with the theory and techniques of operations research. Courses include:

- Design of experiments
- Network flows and graphs
- Stochastic models
- Reliability and weapons system effectiveness
- Inventory theory
- Games of strategy
- Mathematical programming

Students engaged in Interactive Computing Laboratory

WEAPONS ENGINEERING PROGRAMS CURRICULA NUMBERS 530, 531 AND 535



Edward Joseph Mahon, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1957; B.S., Naval Postgraduate School, 1967.

John George Collins, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., U.S. Naval Academy, 1970.

Otto Heinz, Professor of Physics; Academic Associate; B.A., Univ. of California at Berkeley, 1948; Ph.D., 1954.

Several curricular programs are administered by the Weapons Engineering Curricular Office as follows:

530 Weapons Systems Engineering
531 Weapons Systems Science
535 Underwater Acoustics

OBJECTIVE — The fundamental task of the Weapons Engineering subspecialty community is the design, development, test and evaluation, acquisition, operation and support of naval weapon systems. The weapons subspecialist's career pattern must be both technically and operationally sound in order to provide that happy combination of operational and engineering expertise. In support of this career pattern, the objective of these curricula at the Naval Postgraduate School is to provide that advanced technical education on a broad foundation encompassing the basic scientific, analytic and engineering principles underlying the field of naval weaponry. The specific areas of study and the levels of expertise to be attained are formulated for each curriculum to insure a sound basis for technical competence and for subsequent growth as may be required to support the fundamental task of the community.

This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments, and policy making positions, thereby preparing the officer for increased responsibility including command, both ashore and afloat.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with mathematics through differential and integral calculus is required for direct input. Courses in the physical sciences and engineering are highly desirable. Officers not having the required qualifications for direct input enter the program indirectly through the Engineering Science Curriculum discussed elsewhere in this catalog.

Officers may enhance their selectability by taking off-campus courses, including participation in the Postgraduate School Continuing Education program which has been outlined earlier in the catalog.

Allied officers may enroll in the above curricula subject to the exclusion of classified courses as determined by the Chief of Naval Operations.

DESCRIPTION — The structure of each curriculum takes into account the fact that the typical officer student has been away from an academic environment for some time and is not usually prepared to engage in graduate studies without some preparation. The extent of the preparation will depend upon the academic background of the individual officer and will be decided upon by the officer student in consultation with his Curricular Officer and Academic Associate.

The curricula described below are interdisciplinary in nature because of the broad knowledge required of the graduate. Each curriculum consists of a number of basic courses designed to provide a smooth transition from previous studies. In a typical program the first five quarters are devoted to the basic "core" material. Certain undergraduate portions of this core may be validated by an academically prepared officer to permit study to greater depth or breadth at the graduate level, or, subject to course scheduling limitations, to shorten his time on board. The remainder of the program is dedicated to advanced graduate specialization in a specific technical field. Upon successful completion of an approved curriculum, officers will be assigned the appropriate Weapons Engineering subspecialty billet code and will be awarded the degree Master of Science in the appropriate discipline dependent upon academic achievement and successful completion of all requirements. On-going counseling is provided by the curricular Officer/Academic Associate team for all officer students and a close professional relationship between officer student and faculty enables each officer to make his time at the School a valuable asset to his professional development and career.

Descriptions of each curriculum and typical programs follow. Specific degree requirements may be found under the appropriate departmental section of the catalog.

WEAPONS ENGINEERING

Graduate education in weaponry and ordnance systems has long been one of the primary functions of the Naval Postgraduate School. As weapons systems have become increasingly complex, the need to keep pace with the rapidly emerging technology which governs the development and operations of these systems has never been greater. In order to optimally operate, manage and command these complex combat systems, it is essential that officers possess a wide range and depth of basic scientific knowledge in areas such as electronics, controls, lasers, electro-optics, computer systems, communications, radars, signal processing, materials science, explosives and propellants, plasmas, and nuclear science. The Weapons Engineering programs provide graduate-level education in these and other areas of required expertise.

In addition to the formal course work and laboratories, officer students participate in and report on projects designed to investigate components of major weapons systems in order to coordinate and reinforce their experience and their education in considering the "real-life" aspects of weapons systems engineering.

A guest lecture and seminar program, plus visits to weapon-related field activities, serve to keep students informed of current developments and stress the present day utilization of theory and technology.

INTRODUCTORY AND CORE COURSES

The Weapons Systems Engineering and the Weapons Systems Science curricula are identical for the first four quarters. Additionally, eight courses are common to both in the fifth through eighth quarters. The variation between these two curricula is achieved by means of different and varied specialization areas during the last four quarters.

The core portion of the program provides basic mathematical, scientific and engineering courses required for successful pursuit of the graduate electives, as well as those graduate studies required of all officer students. Each student's transcript will be evaluated for validation of as many of the introductory courses as possible. The remaining courses will be programmed with a normal load of four courses each quarter.

The core courses, including some undergraduate level studies, typically cover the following areas:

Calculus, linear algebra, differential equations
Partial differential equations
Mathematical transforms
Probability and statistics
Mechanics and fluid dynamics
Geometrial and physical optics
Atomic and molecular physics
Electromagnetic wave theory and propagation
Electrical circuit analysis, linear systems analysis, control systems
Thermodynamics and explosives technology
Computer modeling and programming
Real-time computer systems
Systems engineering for weapon systems
Military communications and radar systems
Engineering materials and structural failures
Weapons systems design

WEAPONS SYSTEMS ENGINEERING CURRICULUM 530

DESCRIPTION — This program is designed to meet the needs of the military services for an officer having a strong broad-based technical education with particular applications toward weapons systems.

In addition to the introductory and core material previously described, an in-depth option sequence of normally five courses is offered wherein students specialize in particular technical subject areas. Students also engage in thesis research in an area related to these advanced studies.

Graduates are normally awarded the degree Master of Science in Engineering Science. On a case basis, some students, dependent on option courses and undergraduate background, may earn a Master of Science degree in Physics or one of the Engineering disciplines.

In view of the breadth of the 530 curriculum that addresses all aspects of weaponry, successful graduates, regardless of option, will receive the Weapons Systems Engineering subspecialty XX61P.

GRADUATE SPECIALIZATION

For the officer pursuing the Weapons Systems Engineering program, a number of graduate options are available. The availability of these graduate sequences is dependent upon the student's academic qualifications and course scheduling feasibility. Commonly pursued areas of advanced study are:

- Advanced control systems
- Military radar and electronic countermeasure systems
- Electro-optics and laser technology
- Materials science
- Advanced engineering mechanics and analysis
- Advanced military communications theory
- Computer applications to military systems
- Tactical missile design
- Advanced weapons and weapons effects
- Remote sensors and surveillance systems

Other specialization sequences can be designed to meet specific needs, within the limitations of available time and resources.

This curriculum commences each March and October.

WEAPONS SYSTEMS SCIENCE CURRICULUM 531

DESCRIPTION — This program is designed to meet the needs of the military services for officers who have a strong broad-based technical education with graduate emphasis in engineering physics and its applications.

In addition to the introductory and core courses previously described, all students in this curriculum take additional courses in electromagnetic phenomena and statistical physics. An in-depth option sequence of normally five courses is offered wherein students specialize in a particular area of physics. Students also engage in thesis research in an area related to these advanced studies.

Graduates of this curriculum are awarded a degree of Master of Science in Physics. By successful completion of the curriculum the student also earns the XX63P (physics) subspecialty code.

GRADUATE SPECIALIZATION

For the officer pursuing the Weapons Systems Science program, several graduate options are available. The availability of these graduate sequences is dependent upon the student's academic qualifications and course scheduling feasibility. Commonly pursued areas of advanced study are:

- Electro-optics and laser technology
- Advanced weapons and weapons effects
- Remote sensors and surveillance systems
- Military applications of geophysics

This curriculum commences each March and October.

UNDERWATER ACOUSTICS CURRICULUM 535

DESCRIPTION — Underwater Acoustics is an interdisciplinary program. Courses are drawn principally from the fields of physics, electrical engineering, oceanography and mathematics. Although broadly based, the emphasis is on underwater acoustics and signal processing applications to undersea warfare. As can be seen in the following list, courses included relate to the generation and propagation of sound in the ocean, military applications of underwater sound and the electrical engineering aspects of signal processing in sonar systems. Also included are topics concerning the effects of the noise environment on people.

Specific coverage is provided in such areas as propagation of sound in the sea, transducer theory, signal processing electronics, oceanography and noise and vibration control. Successful completion of the curriculum permits the graduate to address the current and future military problems associated with underwater acoustics systems and to expand his base of professional knowledge and technical competence.

As an integral part of his program, each officer prepares a thesis under the guidance of a faculty member. Graduates earn a degree Master of Science in

Engineering Acoustics.

In addition, the program includes short field trips, visits to facilities working on current military acoustic problems, and participation in such meetings as the Navy Symposium on Underwater Acoustics.

Within the Navy, successful completion leads to an approved subspecialty code of XX56P and thus qualifies the graduate officer for assignments to challenging subspecialty billets throughout the military establishment.

A doctoral program leading to the degree Doctor of Philosophy or Doctor of Engineering in Engineering Acoustics is also available for qualified officers. For details see descriptions of programs in Engineering Acoustics elsewhere in this catalog.

INTRODUCTORY STUDY

This portion of the program provides the necessary mathematics, electrical engineering, and physics required for successful pursuit of the graduate curriculum. Each student's transcript will be evaluated for validation of as much material as possible. The remaining studies will be scheduled with a normal load of four courses each quarter.

Calculus review
Linear algebra
Differential equations
Review of basic physics
Thermal and dynamic properties of gases and liquids
Basic circuit theory
Circuit analysis
Communications theory
Electronic engineering fundamentals
Digital machines
Oceanography

GRADUATE STUDY

The graduate portion of the program includes courses in the following areas:

Partial differential equations and integral transforms
Applied probability
Electromagnetic wave propagation
Physics of underwater vehicles
Fundamental acoustics
Underwater acoustics
Propagation of waves in fluids
Transducer theory and design
Advanced acoustics laboratory
Seminar in applications of underwater sound
Mechanical waves in solids
Shock, vibration and noise control in military systems
Sonar systems engineering
Acoustic signal processing
Oceanographic factors in underwater sound

This curriculum commences annually each October.

CURRICULA CONDUCTED AT OTHER UNIVERSITIES

PETER KENNETH STEVENSON, Commander, U.S. Navy; Manager, Civilian Institution Programs; B.S. in Engineering Science, Naval Postgraduate School, 1970; M.S. in Management, 1971.

Curriculum	Number	Length	Institution	Primary Consultant
Chemistry	382	2 yrs.	Various	NAVYSEASYSCOM
Criminal Law	884	1 yr.	Various	JAG
Environmental Law	880	1 yr.	Various	JAG
Facilities Engineering	47X	1-2 yrs.	Various	NAVFACENGCOM
Forensic Science	885	1 yr.	Armed Forces Inst. of Pathology*	JAG
International Law	887	1 yr.	George Wash. Univ.*	JAG
Joint Intelligence	990	9 mos.	Defense Intell. Sch.*	NAVINTCOM
Labor Law	886	1 yr.	Various	JAG
Law (Army Judge Advocate Officers Adv. Course)	881	9 mos.	U. of Virginia	JAG
Logistics Management	700	1 yr.	Air Force Inst. of Technology*	CHNAVMAT
Naval Const. & Engrg.	510	2-3 yrs.	M.I.T.	NAVSEASYSCOM
Nuclear Effects (Phys)	521	18 mos.	Air Force Inst. of Technology*	DEFNUCAGCY
Nuclear Engineering (CEC)	572	18 mos.	Penn State Univ	NAVFACENGCOM
Nuclear Engineering (ED)	520	18 mos.	Penn State Univ	NAVSEASYSCOM
Ocean Engineering	472	1-2 yrs.	Various	NAVFACENGCOM
Ocean Law	883	1 yr.	Various	JAG
Petroleum Engineering	630	1-2 yrs.	U. of Texas	NAVFACENGCOM
Petroleum Management	811	17 mos.	U. of Kansas	NAVSUPSYSCOM
Pol-Mil (Western Hemisphere)	685	18 mos.	Various	CNO
Public Affairs	920	1 yr.	Various	CHINFO
Religion	970	9 mos.	Various	CHCHAP
Retailing	830	1 yr.	Michigan St.*	NAVSUPSYSCOM
Subsistence Technology	860	1 yr.	Michigan St.*	NAVSUPSYSCOM
Supply Aquis/Distrib Mgmt	810	12-18 mos.	Various	NAVSUPSYSCOM
Taxation	882	1 yr.	Various	JAG

**No NROTC Unit at Institution*

ACADEMIC DEPARTMENTS AND COURSE DESCRIPTIONS

The faculty of the Naval Postgraduate School performs its graduate-education functions in an organizational arrangement that includes eleven academic departments and three interdisciplinary academic groups, each headed by a designated chairman. The departmental affiliations of the faculty members, the advanced degree offerings, and the courses of study are contained in the individual department descriptions which follow.

In support of the courses of study, an active research program is carried on by the faculty and students. The research projects are supported by the Office of Naval Research, the Director of Naval Laboratories, the various Naval Systems Commands, and the National Science Foundation, as well as by other agencies and organizations. The ongoing projects cover a broad spectrum of research problems and include both theoretical and experimental investigations.

The faculty maintains close liaison with programs at Department of Defense research laboratories and development centers, and the knowledge acquired and maintained through this association is incorporated throughout the instructional program. Faculty members are formally cleared for classified matter, and storage and control facilities are available for all levels of security classification. This allows both students and faculty full access to classified material as needed.

The undergraduate-level courses included in the departmental offerings are taken by students, as required, to prepare them for the graduate-level program. Much of this preparatory subject matter is available for off-campus self-study through the School's Continuing Education Program. Information concerning the availability of a course in this study mode is included in the course description.

DEPARTMENT OF ADMINISTRATIVE SCIENCES

Instructional activities in Administrative Science

Carl Russell Jones, Professor of Administrative Sciences: Chairman (1965)*, B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

James Kenichi Arima, Associate Professor of Behavorial Science (1969); B.A., Univ. of California at Los Angeles, 1948; M.A., George Washington Univ., 1957; Ph.D., Northwestern Univ., 1962.

John Roy Bergquist, Lieutenant Commander, S.C., U.S. Navy; Instructor in Acquisition Management (1981); B.A., Univ. of Minnesota, 1963; M.S., Naval Postgraduate School, 1979.

Peter William Blondin, Commander, U.S. Navy; Instructor in Financial Management (1981); B.S., Quinnipiac College, 1963; M.B.A., Harvard Business School, 1971.

Robert Alexander Bobulinski, Lieutenant Commander, U.S. Navy; Instructor in Accounting (1979); B.S., Pennsylvania State Univ., 1969; M.S., Naval Postgraduate School, 1976.

Dan Calvin Boger, Assistant Professor of Economics (1979); B.S., Univ. of Rochester, 1968; M.S., Naval Postgraduate School, 1969, M.A., Univ. of California at Berkeley, 1977; Ph.D., 1979.

Philip Bromiley, Assistant Professor of Financial Management (1981); B.A., The Johns Hopkins Univ., 1974; Ph.D., Carnegie-Mellon Univ., 1981.

Earl Roy Brubaker, Adjunct Professor of Economics (1980); B.S., Pennsylvania State Univ., 1954; Ph.D., Univ. of Washington, 1964.

Phillip Neal Butler, Captain, U.S. Navy; Assistant Professor of Organizational Sciences (1979); B.S., U.S. Naval Academy, 1961; M.A., Univ. of California at San Diego, 1975; Ph.D., 1981.

Paul Marshall Carrick, Associate Professor of Management (1969); B.A., Northwestern Univ., 1949; Ph.D., Univ. of California at Berkeley, 1956.

John Wallis Creighton, Professor of Management (1967); B.S., Univ. of Michigan, 1938; B.A., Hastings College, 1939; Ph.D., Univ. of Michigan, 1954.

William Henry Cullin, Adjunct Professor of Acquisition Management (1981); M.S., Massachusetts Institute of Technology, 1947; M.S., Univ. of Southern California, 1975.

Leslie Darbyshire, Professor of Management (1962); B.A., Univ. of Bristol, 1950; D.B.A., Univ. of Washington, 1957.

Richard Sanford Elster, Professor of Management and Psychology (1969); B.A., Univ. of Minnesota, 1963; M.A., 1965; Ph.D. 1967.

Carson Kan Eoyang, Associate Professor of Management (1974); B.A., Massachusetts Institute of Technology, 1966; M.B.A., Harvard Univ., 1968; Ph.D., Stanford Univ., 1976.

Kenneth James Euske, Assistant Professor of Accounting (1978); A.B., Gonzaga Univ., 1967; M.B.A., Dartmouth College, 1969; D.B.A., Arizona State Univ., 1978.

Roger Dennis Evered, Associate Professor of Administrative Sciences (1979); B.S., Univ. of London, 1953; M.S., Univ. of California at Los Angeles, 1972; Ph.D., 1973.

James Morgan Fremgen, Professor of Accounting (1965); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., State of Indiana, 1964.

Francis David Harding, Adjunct Professor of Management (1981); B.S., Boston Univ., 1947; M.S., Univ. of Illinois, 1948; Ph.D., Purdue Univ., 1953.

Reuben Travis Harris, Associate Professor of Organizational Behavior and Management (1978); B.S., Antioch College, 1969; M.B.A., Univ. of Rochester, 1972; Ph.D., Stanford Univ., 1975.

Fenn Clark Horton, Associate Professor of Economics (1964); B.A., State Univ. of Iowa, 1950; M.A., Claremont Graduate School, 1967; Ph.D., 1968

Miles Hartley Kennedy, Adjunct Professor of Information Systems (1981); B.A., Univ. of Toronto, 1952; Ph.D., 1971.

Melvin Bernard Kline, Professor of Management (1970); B.S., College of the City of New York, 1941; M.S., Stevens Institute of Technology, 1952; M.E., Univ. of California at Los Angeles, 1959; Ph.D., 1966.

Shu Sheng Liao, Associate Professor of Accounting (1977); B.A., National Taiwan Univ., 1965; M.S., Utah State Univ., 1968; Ph.D., Univ. of Illinois, 1977.

Meryl Reis Louis, Assistant Professor of Management (1979); B.S., Univ. of California at Los Angeles, 1967; M.S., 1968; Ph.D., 1978.

Norman R. Lyons, Associate Professor of Management Information Systems (1979); B.S., Stanford Univ., 1966; M.S.I.A., Carnegie-Mellon Univ., 1970; Ph.D., 1972.

Richard Allin McGonigal, Associate Professor of Management (1974); B.S., Cornell Univ., 1951; B.D., Union Theological Seminary, 1954; S.T.M., Columbia Univ., 1966; Ph.D., Michigan State Univ., 1971.

Alan Wayne McMasters, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

Joseph Francis Mullane, Lieutenant Colonel, U.S. Marine Corps; Instructor in Administrative Sciences (1981); B.S., Ohio State Univ., 1963; M.S., Naval Postgraduate School, 1977.

Robert Gordon Nickerson, Lieutenant Commander, U.S. Navy; Assistant Professor of Administrative Sciences (1977); B.S., U.S. Naval Academy, 1963; M.S., Stanford Univ., 1967; Ph.D., 1975.

Marie-Solange Perret, Assistant Professor of Accounting (1981); Licence Es Sciences Economiques, Univ. of Lyon, 1967; M.B.A., European Institute of Business Administration, (1968); Ph.D., Univ. of Western Ontario, 1980

Clair Alton Peterson, Associate Professor of Economics (1962); B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961.

Norman Floyd Schneidewind, Professor of Information Science and Computer Science (1971); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966; C.D.P., 1976.

John David Senger, Professor of Management and Behavorial Sciences (1957); B.S., Univ. of Illinois, 1945; M.S., 1948; Ph.D., 1965.

Marshall Lewis Sneiderman, Commander, U.S. Navy; Instructor in Administrative Sciences (1979); B.S., Pennsylvania State Univ., 1961; M.B.A., Univ. of Michigan, 1971.

George William Thomas, Adjunct Professor of Economics (1978); B.S., Southern Illinois Univ., 1967; M.S., Purdue Univ., 1969; Ph.D., 1971.

Roger Weissinger-Baylon, Associate Professor of Management Information Systems (1979); B.S., Massachusetts Institute of Technology, 1967; M.S., 1971; Ph.D., Stanford Univ., 1978.

Ronald Alfred Weitzman, Associate Professor of Psychology (1971); B.A., Stanford Univ., 1952; M.A., 1954; Ph.D., Princeton Univ., 1959.

David Richard Whipple, Jr., Associate Professor of Economics and Systems Analysis (1971); B.A., Univ. of St. Thomas, 1964; M.A., St. Mary's Univ., 1966; Ph.D., Univ. of Kansas, 1971.

Chester Arthur Wright, Assistant Professor of Social Psychology (1973); B.A., San Francisco State Univ., 1965; M.S., Univ. of California at Los Angeles, 1968.

Emeritus Faculty

William Howard Church, Professor Emeritus (1956); B.A., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be arranged in consultation with the Chairman, Department of Administrative Sciences.

MASTER OF SCIENCE IN APPLIED SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in administrative sciences at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Department of Administrative Sciences. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

MASTER OF SCIENCE IN INFORMATION SYSTEMS

1. A candidate for the degree Master of Science in Information Systems must successfully complete or validate core courses in each of the following disciplines:

Accounting and Financial Management
Organizational Sciences
Information Systems
Computer Science
Economics
Management Theory and Practice
Quantitative Methods

2. In addition, the candidate must successfully complete 48 quarter hours of graduate-level course work and an acceptable thesis or project. At least 12 quarter hours of the course work must be at the 4000-level. Further, this graduate-level course work must include at least 24 quarter hours in the administrative sciences and at least 16 quarter hours in computer science.

3. The candidate's program must be approved by the chairperson of the Department of Administrative Sciences.

MASTER OF SCIENCE IN TELECOMMUNICATIONS SYSTEMS MANAGEMENT

The degree of Master of Science in Telecommunications Systems Management will be awarded at the completion of an interdisciplinary program that satisfies the following requirements:

1. A minimum of 56 quarter hours of graduate-level work of which at least 12 quarter hours must represent courses at the 4000 level.

2. The program must consist of a minimum of graduate-level credit as follows:

Administrative Sciences and Quantitative Methods	40
Communications Systems and Computer Science	16

3. In addition to the 56 quarter hours of graduate-level course credit, an acceptable thesis shall have an advisor and a second reader, at least one of whom must be from the Department of Administrative Sciences.

MASTER OF SCIENCE IN MANAGEMENT

The award of the degree of Master of Science in Management requires:

1. Completion of the Management Fundamentals program plus a minimum of eight (8) quarter hours of upper division courses in subjects directly pertinent to the nature and objectives of the particular curriculum. The Management Fundamentals program consists of a total of 34 quarter hours of 2000 and 3000 level courses, including a minimum of the following hours by disciplines:

Accounting and Financial Management	6
Behavioral Science	3
Economics	6
Management Theory	3
Quantitative Methods	8

2. The completion of a minimum of forty (40) quarter hours of graduate level courses, at least twelve (12) quarter hours at the 4000 level.

3. The completion of an approved sequence of courses in the student's area of concentration. Examples of concentration areas are accounting and financial management, communications management, economics, management science, material management, personnel management, and systems acquisition management.

4. In addition to the 40 quarter hours of course work, the submission of an acceptable thesis on a topic previously approved by the Department of Administrative Sciences.

5. Final approval of a program leading to the Master of Science in Management shall be obtained for each student from the Chairman, Department of Administrative Sciences.

DEPARTMENTAL COURSE OFFERINGS

SERVICE COURSES

Upper Division Course

AS 2701 Introduction to Systems Engineering (3-0 to4-0).
This course provides the student with an introduction to system design and development, the underlying philosophy concepts and methodology of systems engineering and its application in the Department of Defense and the Navy. It establishes the foundation for other courses in the Weapon Systems Technology (WST) option of curriculum 530. Topics covered include systems engineering overview, the systems approach, the system life cycle and the system design process, systems engineering disciplines. Emphasis is placed on the planning and design phases of the system life cycle.

Upper Division or Graduate Courses

AS 3204 Defense Resource Analysis (4-0).
The aim of this course is to present the nature, the aims, and limitations of analysis as it exist today and contributes to military problems. The common principles of cost/effectiveness analysis, design and formulation of the study, methods of solution, sensitivity analysis, pitfalls and limitations. Case studies from the field of interest of the class will be discussed.

AS 3340 The Defense Decision Process and ASW (4-0).
Study of the defense decision process as it relates to the choice of ASW forces. Includes consideration of the systems acquisition system, the planning, programming and budgeting system, the use of decision and cost-effectiveness analysis, and their interrelationship in setting the ASW force level and mix. Case studies are used to illustrate. PREREQUISITES: OS 2102 (for EE), or OS 2103 (for ASW/EW) or equivalent, OS 3602.

AS 3501 Project Management (4-0).
This course provides the student with an understanding of the unlying philosophies and concepts of the systems acquisition process and the practical application of project management methodologies within this process. Topics include the evolution and current state of systems acquisition management; the fiscal cycle and PPBS; the defense systems acquisition cycle; user-producer acquisition management disciplines and activities; and project planning, organization, staffing, directing, and controlling. *(Open only to students not enrolled in Administrative Sciences curricula, Telecommunication Systems curriculum or Computer Systems curriculum.)*

AS 3510 Organizational Behavior and Naval Intelligence (4-0).
An examination of the different approaches to the study of organizations and their relevance to the administration of Naval intelligence. Topics include theories of organization, diagnostic models of organizational action, measures of organizational effectiveness, and case studies of organizational behavior.

AS 3610 Economic Analysis and Operations Research (4-0).
A presentation of basic economic concepts involved in the decision processes of individuals and groups faced with scarcity of resources. Topics covered include consumer theory and demand, individual behavior under uncertainty, producer theory and supply, firm behavior under uncertainty, output and input market structures, partial and general equilibrium analysis, and market imperfections and welfare analysis. PREREQUISITES: MA 2042, MA 2110 (concurrently), OA 3201 (concurrently).

AS 3611 Planning and Capital Allocation in the Department of Defense (4-1).
Extension of concepts discussed in AS 3609 to allocation of resources over time. Covered are models of consumption and production overtime, optimal investment decision rules and investment under uncertainty. Models of welfare economics and cost-benefit analysis are presented. Also covered are planning and decentralization techniques using decomposition algorithms. Cost effectiveness and costing models from current practices in DoD are examined. Institutional procedures and processes such as PPBS, budget enactment and apportionment, FYDP, systems acquisition/DSARC and ZBB are also discussed. PREREQUISITES: AS 3610, OA 3103.

AS 3703 Maintainability Engineering (4-0).
Maintainability as a system design discipline. The system of life cycle/decision process and maintainability. The maintainability program plan (MIL-STD-470). Maintenance engineering analysis. Developing the maintenance concept. Concepts of system effectiveness — reliability, maintain ability, availability, dependability, and capability. Maintainability statistics, prediction, demonstration, and evaluation. (MIL-STD-471). Maintainability design requirements and tradeoff analysis. Maintainability program management, design reviews, data collection. Case studies and examples. PREREQUISITE: A course in probability and statistics.

AS 3704 Logistics Engineering (4-0)
Integrated logistics support as a systems engineering discipline. Logistic support planning and the system life cycle. Logistics elements. Logistic support analysis (MIL-STD-1338). Level-of-repair analysis (MIL-STD-1390). Statistical techniques for logistics, resource analysis, provisioning and inventory control. Logistics interfaces with reliability and maintainability. Data requirements. Logistics management. PREREQUISITES: An introductory course in probability and statistics and a survey course in operation research.

Graduate Course

AS 4613 Theory of Systems Analysis (4-0).
Systems analysis (cost-effectiveness analysis) formulated as commensurable and incommensurable physical capital investment choice models. Emphasis on decision rules and the nature of opportunity costs with respect to scale and timing of investment. Interpretation of methods of risk, modeling and solution computation. Theory of the second best; theory of the social discount rate. Introduction to models of planning and control emphasizing decentralization of the decision-making problem. PREREQUI— SITES: AS 3611, OA 4201 (concurrently).

TELECOMMUNICATIONS SYSTEMS MANAGEMENT

CM 0001 Seminar for Telecommunications Management Students (0-2).
Guest lecturers, Thesis and research presentations.

CM 0810 Thesis Research for Telecommunications Management Students (0-0).
Every student conducting thesis research will enroll in this course.

Graduate Course

CM 4925 Telecommunications: Systems, Industry, Regulation (4-0).
Study of the telecommunications industry (domestic and international) and its regulation (Congress and Executive Branch, Federal Communications Commission, International Telecommunications Union). Considerations of special issues: allocation of the spectrum, telecommunication service pricing, DOD lease decisions, and DOD supply of services. PREREQUISITES: IS 3170, OS 3005.

INFORMATION SYSTEMS

IS 0001 Seminar for Computer Systems Management Students (0-2).
Guest Lecturers. Thesis and research presentations.

IS 0810 Thesis Research for Computer Systems Management Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Course

IS 2000 Introduction to Computer Management (3-0).
This course will provide an introduction to the field of automatic data processing and the functions and responsibilities of the computer manager. Specific topics are: survey of comtemporary computer applications, hardware and software: functions and responsibilities of the computer manager; introduction to the role of personnel management, financial management, quantitative methods and computer science in computer management.

Upper Division or Graduate Courses

IS 3000 Distributed Computer Systems (4-0).
This course covers the technology, application and management of distributed computer systems. Specific topics include distributed processing, distributed data base management, communication facilities and protocols, economic and performance analysis, and managerial and organizational problems. PREREQUISITES: CS 2810, (CS 3010 or CS 3400) and IS 3170 (concurrently).

IS 3100 Survey of Contemporary Computer Systems (3-0).
Study and analysis of contemporary large, mini and micro computer systems, including hardware, applications of software, operating systems and price characteristics. Emphasis is on the study and comparison of specific vendor systems which are available in the marketplace and evaluation of their applicability to various military requirements. Trends in computer technology and pricing structures. PREREQUISITES: CS 2810, (CS 3010 or CS 3400), (CS 3030 or CS 3112) and IS 3170).

IS 3170 Economic Evaluation of Information Systems I (4-0).
The study of economic evaluation concepts and methods for planning, budgeting and controlling computer based information systems design, implementation and analysis. Topics included are cost performance (value) analysis, capacity planning, capitol budgeting techniques, capitol budgeting systems, budgeting and pricing for computer services and a study of the Information Industries (computers, software and telecommunications). PREREQUISITE: MN 2155.

IS 3171 Economic Evaluation of Information Systems II (4-0).
A continuation of IS 3170. PREREQUISITE: IS 3170.

IS 3183 Management Information Systems (4-0).
Study of what an information system is, how the computer and other resources fit into the system, and management considerations involved in computer-based and other information systems. Study of computer and MIS concepts. PREREQUISITE: CS 2010, MN 3105, CS 2106 (concurrently).

IS 3184 Management Information Systems and the Computer (4-0).
Study of what an information system is, how the computer and other resources fit into the system, and management considerations involved in the Intelligence Data Handling System and other information systems. Study of basic computer and MIS concepts as required, including computer and data structures, input/output systems and file organization. Survey of COBOL programming and data-base management languages. This course is for 825 Naval Intelligence students only.

IS 3185 Information Systems for C3 (4-0).
Study of what constitutes a Military Information system relative to command, control, and communications (C3). Includes concepts of systems theory, computer networks, value of information, distributed data processing, and human behavior. Emphasis on the role of information processing in joint C3 Applications. Organizational considerations which may enhance or impede use of a MIS are introduced. This course is designed for Command, Control, and Communications students and will be taught in part at the SECRET level. PREREQUISITES: CS 2810, CO 3111.

IS 3186 Selected Topics in Information Systems (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

IS 3220 Computer Center Operations (3-2).
Theory and practice of the management of computer center operations. Specific topics include facilities planning, production scheduling and control, operational procedures, and computer performance evaluation. A feature of the course is experience obtained in operating the NPS Computer Center installation. PREREQUISITES: CS 3030, and OS 3004 or equivalent.

Graduate Courses

IS 4133 Economics of Computers (4-0).
Analytical tools of microeconomics and statistics applied to decision making in computer management. Economics issues and legal constraints related to computer hardware and software systems are discussed. PREREQUISITE: IS 3171.

IS 4181 Applications of Management Information Systems (4-0).
Advanced study of management information as it relates to various organizational systems. Students will study actual industrial and/or military organizations in the context of management information systems. The issues of design, implementation, and operation of a management information system will be considered through the use of case studies of industrial and military organizations. This course is primarily for management students. PREREQUISITE: IS 3183.

IS 4182 Data Processing Management (4-0).
Management of the ADP in the Federal Government, especially in the Department of Defense. Specific topics covered include: Computer Center and Computer System development management; procurement of computer systems; installation and effective utilization of ADP systems. PREREQUISITE: IS 4200.

IS 4183 Applications of Database Management Systems (4-0).
Applications-oriented introduction to database management systems technology. Survey of current database systems and approaches to database technology. Technical and administrative considerations involved in a database implementation project are considered. Students will be expected to implement an applications system using a database management package. PREREQUISITES: CS 3010, CS 3020, IS 2000.

IS 4184 Real-Time Information System Management (4-0).
Management and design of real-time systems. Topics include real-time system and software characteristics; software management; real-time system development; management including analysis, design, programming and testing, operation and computer evaluation and selection; real-time system design including networks, files, reliability, security and accuracy. PREREQUISITE: CS 3502.

IS 4185 Computer-Based Management Information Systems (4-0).
The application and design of computer-based information systems for management planning, control and operations. PREREQUISITES: MN 2155, MN 3105, OS 3101 and IS 2000, or equivalent.

IS 4200 System Analysis and Design (4-0).
This course covers computer-based system development including the concepts, methodologies and techniques of: information system requirements analysis, technical and economic feasibility studies, system costing, functional specifications, computer and data communication hardware and software trade-off evaluations and specifications, conversion and testing. PREREQUISITES: (CS 2810, CS 3010, and CS 3020) or (CS 2810, CS 3111, and CS 3400).

IS 4925 Selected Topics in Information Systems (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITES: A background of advanced work in information systems and Departmental approval.

MANAGEMENT

MN 0001 Seminar for Management Students (0-2).
Guest Lecturers. Thesis and research presentations.

MN 0810 Thesis Research for Management Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

MN 2031 Economic Decision Making (4-0).
The macroeconomic section includes a presentation of methods of national income determination, the consumption function and multiplier concepts, and the impact of fiscal and monetary policies. The microeconomic section covers an introduction to individual economic decision processes and their relation to attainment of market equilibria. PREREQUISITE: MA 2300 (concurrently).

MN 2106 Organizational Systems I (4-0).
Study of individual and group behavior in organizational contexts. Emphasis is on the impact of perception, motivation, communication, personality, group behavior, and leadership on performance and satisfaction within formal organizations. *(May be taken through Continuing Education as mini-courses MN 2107-09.)*

MN 2150 Financial Accounting (4-0).
Study of basic accounting concepts and standards. Specific topics include the accounting cycle, asset valuation, equities and capital structure, earnings measurement, cash-flow analysis, and financial-statement analysis. *(May be taken through Continuing Education.)*

MN 2155 Accounting for Management (4-0).
Brief introduction to financial accounting, with emphasis on the content and analysis of financial statements. Specific topics in management accounting include fundamentals of cost accounting, cost-volume analysis, budgeting, relevant costs for decision making, capital budgeting, and financial performance measures. (Closed to students who must take or have taken MN 2150 and MN 3161.)

Upper Division or Graduate Courses

MN 3001 Behavioral Research Methodology (4-2).
Statistical analysis of human response data for purposes of managerial prediction and control: Survey and research design. Natural experiments. Concepts and applications of correlational methods, factor analysis, multiple regression, and cross-validation, as well as conceptual overview of analysis of variance. PREREQUISITES: MN 3105 and either OS 3102, OS 3103 or OS 3101.

MN 3101 Personnel Management and Labor Relations (4-0).
Study of the principles and practices of personnel administration in business and government organizations. A survey of the history, development, and current status of labor-management relations in industry and government. Analysis of the labor market and the implications of government regulations for wages and labor-management bargaining. PREREQUISITES: MN 3105 and at least two quarters of postgraduate work in management.

MN 3105 Organizational Systems II (4-0).
Study of managing organization as a dynamic environment. Emphasis is on managerial decision making, planning and control, organizational structure and planned organizational change and their systemic impacts on organizational effectiveness and adaptation. PREREQUISITE: MN 2106. *(May be taken through Continuing Education.)*

MN 3110 Individual Behavior (4-0).
Study of the basic characteristics and determinants of individual behavior. Specific topics include personality, motivation, learning, behavior conditioning, and introduction to tests and measurement. Implications for effective administrative practice. PREREQUISITE: MN 2106.

MN 3111 Personnel Management Processes I (4-0).
A broad coverage of human behavior in the work situation with special emphasis on the problem of work in the Naval environment. Topical areas covered include selection, placement, training, and evaluation of personnel; motivation, remuneration, morale, supervision, and working conditions in organizations; equipment design and man-machine relationships; and consumer (user) behavior and the impact of technological programs. PREREQUISITES: MN 3105, OS 3103 (concurrently).

MN 3112 Selected Topics in Human Resources (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3114 Organization Development I (4-2).
A comprehensive survey of theories and methods of planned organizational change. Topics include assumptions and values of organization development, consulting strategies, diagnostic techniques, intervention design, implementation, and evaluation. PREREQUISITE: MN 3105.

MN 3116 HRM Field Work (0-4).
A laboratory course to accompany Organization Development II (MN 4123). Emphasis is upon supervised interventions with ongoing military HRM projects. Students are expected to be in the field 4 weeks. PREREQUISITE: MN 4123 (concurrently).

MN 3117 Workshop Design (0-4).
A practicum designed as a companion course to Education and Training (MN 4116) to give students experience in designing, developing, implementing, and assessing HRM workshops. PREREQUISITE: MN 4116 (concurrently).

MN 3121 Leadership and Group Behavior (4-0).
The study of groups in different settings and factors affecting both individual and group behavior. Attention will be given to such concepts as authority, conformity, cohesiveness, effectiveness, and leadership. Emphasis will be placed on methods of observing group action. PREREQUISITE: MN 2106.

MN 3123 Military Sociology (4-0).
An exploration of classical theories of sociology pertaining to civil-military relations with modern applications to command and control problems. Sexism, racism, family dissolution, unionization, bureaucratic inertia, career patterns and professionalism are considered from the perspective of sociology. PREREQUISITES: MN 2106, MN 3105.

MN 3124 Analysis of Bureaucracy (4-0).
An analysis of the forms and processes of complex organizations in evolution from charisma to bureaucracy. Topics include formal dimensions of structure, informal structure, professionalism, basic growth and elaboration processes, and applications of general systems theory to organizational phenomena. PREREQUISITE: MN 3105.

MN 3126 Selected Topics in the Behavioral Sciences (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3130 Macroeconomic Theory (4-0).
Development of models to analyze the relationships between aggregate consumption, investment and output. Consideration of debt and financial assets, technical progress, growth, and monetary and fiscal control systems. PREREQUISITE: A course in Principles of Economics.

MN 3135 Selected Topics in Economics (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in economics and Departmental approval.

MN 3140 Microeconomic Theory (4-0).
Determination of the allocation of resources and the composition of output. Consumer and Producer Choice Theory. Partial and general equilibrium analysis. Welfare economics. Applications to defense problems are emphasized. PREREQUISITES: MN 2031, MA 2300 or their equivalents.

MN 3142 International Trade and Development (4-0).
Study of the nature of trade between nations and the various approaches to economic development. Topics include trade and resource allocation, international finance, growth and development theory, and the market-public planning for development debate. Policy issues are considered with emphasis on the implications for national action. PREREQUISITE: A course in Principles of Economics.

MN 3146 Comparative Economic Systems (4-0).
The characteristics and functions of economic systems. Criterial for evaluating performance. The analysis of alternative patterns of control, planning and market structures under capitalism, socialism, and mixed economics. PREREQUISITE: A course in Principles of Economics.

MN 3161 Managerial Accounting (4-0). Introduction to cost accounting, including overhead costing, job order and process systems, variable and absorption costing, and standard cost. Emphasis is on applications of accounting data to planning, control, and decision making. Topics covered include budgeting, flexible budgets, standard costs and variance analysis, performance measures, cost-volume-profit analysis, cost analysis for decision making, and capital budgeting. PREREQUISITE: MN 2150. *(May be taken through Continuing Education.)*

MN 3165 Selected Topics in Accounting and Financial Management (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. The course may be repeated for credit if course content changes. PREREQUISITE: A background in accounting and financial management and Departmental approval.

MN 3172 Public Policy Processes (4-0). A presentation by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. PREREQUISITES: MN 3140, MN 3161, MN 3105. *May also be offered as NS 3172.*

MN 3215 Selected Topics in Management Science (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3301 Introduction to Systems Acquisition and Project Management (4-0). This course provides the student with an understanding of the underlying philosophies and concepts of the systems acquisition process and the practical application of project management methodologies within this process. Topics include the evolution and current state of systems acquisition management; the defense systems acquisition cycle; user-producer acquisition management disciplines and activities; and project planning, organization, staffing, directing, and controlling. PREREQUISITE: MN 3105 or equivalent. *Restricted to management students not enrolled in the Acquisition and Contracting curriculum.*

MN 3302 Seminar for Acquisition and Contracting Students (0-3). Guest lecturers. Thesis and research presentations. Certified Professional Contracts Manager (CPCM) certificate examinations. *Graded on Pass/Fail basis only.*

MN 3303 Principles of Acquisition and Contracting (4-0). Introduction to the principles of acquisition and contracting. This course studies the fundamentals of the Defense Acquisition Regulation (DAR) and the Federal Acquisition Regulation (FAR); the acquisition and contracting processes including the determina- of need, acquisition strategies, basic contract law, ethics, and contracting methodologies; and acquisition/contracting management techniques. PREREQUISITES: Enrolment in the Acquisition and Contracting Management curriculum, MN 3105 or equivalent.

MN 3304 Contract Pricing and Negotiations (4-0). This course involves the study of pricing theory and strategies, costing methodologies, cost and price analysis, cost principles, cost accounting standards, and contract negotiations. Students develop and sharpen negotiation skills by participating in practical negotiation exercises. PREREQUISITES: MN 3303, MN 3140, OS 3102.

MN 3305 Contract Administration (4-0). This course stresses the management skills and techniques necessary for the successful administration of Government prime contracts and subcontracts. Topics include managing contract progress and performance change control, quality control, cost/financial control, property, terminations, and regulatory and policy concerns. PREREQUISITES: MN 3303.

MN 3307 A.D.P. Acquisition (4-0). Introduction to the management principles, concepts and issues involved in Federal Government acquisition of ADP requirements. The course focuses on the concepts of system acquisition project management as they pertain to ADP Acquisition and specific buying of both computer hardware and software and administration issues through case study analysis. PREREQUISITE: Computer Systems student, or permission of Instructor.

MN 3308 Introductions to Systems Engineering (4-0).
This course provides the student with an introduction to system design and development, the underlying philosophy, concepts, and methodology of systems engineering, and its application in the Department of Defense and the Navy. It establishes the foundation for later courses in reliability, maintainability, and logistics. Topics covered include systems engineering overview, the system life cycle and system design process, decision analysis, and the systems engineering disciplines. Emphasis is placed on the planning and design phases of the system life cycle. PREREQUISITE: A course in statistics.

MN 3309 Maintainability Engineering (3-0).
The maintainability program plan (MIL-STD-470). Maintenance engineering analysis. Developing the maintenance concept. Concepts of system effectiveness — reliability, maintainability, availability, dependability, and capability. Maintainability statistics, prediction, demonstration, and evaluation (MIL-STD-471). Maintainability design requirements and trade-off analysis. Maintainability program management, design reviews, data collection. Case studies and examples. PREREQUISITE: MN 2308 or a course in statistics.

MN 3310 Manpower Personnel Planning and Analysis (4-0).
Examines procedures and principles for establishing positions and acquiring and administering staff personnel, including pertinent aspects of industrial relations. Reviews principles, procedures, and practices for establishing qualitative and quantitative personnel and training requirements for new systems and major modifications. PREREQUISITES: MN 2106 and MN 3105 (concurrently).

MN 3311 Acquisition Management Simulation (0-4).
This course is a system life cycle, computer-based simulation, interactive laboratory exercise in which the students, in teams, plan, organize, and manage the development and production of a missile system. Trade-offs among performance, reliability, cost, and schedule, evaluation of technical proposals, contract and incentive negotiations, and DSARC reviews are included. PREREQUISITE: MN 3301 or AS 3501 or MN 3303 (concurrently).

MN 3371 Contracts Management and Administration (4-0).
Study of the characteristics/phases of the contracting process. Coverage includes planning, execution and control of the contracting process; techniques used in purchasing goods and services of varying complexities; and the relationship of contracting to the acquisition process. PREREQUISITE: MN 3105 or consent of instructor.

MN 3372 Material Logistics (4-0).
The quantitative analysis of material logistics systems and supply management problems. Elements of study include inventory theory, data reporting, forecasting, order processing, and system-wide design problems. PREREQUISITES: MN 3105 and OS 3103 (concurrently).

MN 3373 Transportation Management (4-0).
Provides a knowledge of problems and practices encountered in the management of transportation systems. Areas covered include the study of present and future trends in military and commercial transportation systems. PREREQUISITE: MN 3140.

MN 3374 Production Management (4-0)
This course examines the production process. Emphasis is distributed among the technical, managerial, and defense aspects of production. Topic coverage ranges from production planning through production control. PREREQUISITES: MN 3105 and OS 3103 and OS 3006

MN 3376 Selected Topics in Material Logistics (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3645 Investigative Methods of Economics I (4-0).
Development and applications of econometric models of particular interest to public sector managers. Topics include demand forecasting, production function estimates, and cost estimating. PREREQUISITES: MN 3140 and OS 3006 (concurrently).

MN 3650 Health Economics (4-0).
An overview and analysis of the underlying elements of the continuing problems in the military and civilian health care delivery

sectors. Elements covered are: organizational structure and change in the mode of delivery of health care; supply, demand and output and quality measurement of health services; the impact of health care legislation; the relationship of the military and civilian sectors. PREREQUISITE: Microeconomics, e.g. MN 3140, AS 3610 or equivalent.

MN 3760 Manpower Economics I (4-0).
This course contains both theoretical and empirical issues in manpower economics. The theoretical development emphasizes individual employment, job searching, mobility, and career decisions. Empirical work presented may include studies on the all-volunteer force, hazardous duty compensation and reenlistment bonuses. PREREQUISITE: MN 3140

MN 3801 Seminar in Technology Transfer (4-0).
The study of dissemination and utilization of technology and associated problems with emphasis on communications, sociology, and organizational factors. PREREQUISITE: MN 3105 or graduate standing in a technical curriculum with consent of Instructor.

MN 3970 Seminar in Management (2-0 to 5-0).
Content of course varies. Students will be allowed credit for taking this course more than one time. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

Graduate Courses

MN 4105 Management Policy (4-0).
Study and analysis of complex managerial situations requiring comprehensive integrated decision making. Topics include operational and strategic planning, policy formulation, executive control, environmental adaptation, and management of change. Case studies in both the public and private sectors are emphasized. PREREQUISITE: Open only to students in their final quarter of a Management Masters program.

MN 4106 Manpower Personnel Policy Analysis (4-0).
Study and analysis of manpower/personnel policy alternatives with emphasis on identifying the trade-offs involved, the dynamic impact of major policy decisions, and the short-term and long-term consequences of decisions. Review, use, and evaluation of tools to aid in selecting policy alternatives. Study of representative cases. PREREQUISITE: Open only to students in their final quarter of the Manpower-Personnel Analysis curriculum.

MN 4110 Personnel Management Processes II (4-0).
Emphasizes the integration of specific personnel management procedures and practices into programs with special emphasis on areas of current interest to military and civilian personnel administration. Programs will be examined with respect to their background and objectives, specific actions being taken and the rationale therefore, and factors impacting on their potential success and failure. The management of manpower-personnel research, development, and implementation will be revised. PREREQUISITE: MN 3111.

MN 4111 Human Resources Seminar (4-0).
A combination of readings and individual student research reports in the area of human resource goals. Emphasis on empirical analysis. PREREQUISITE: Departmental approval.

MN 4112 Personnel Selection and Classification (4-0).
Study of methods available for evaluating and predicting work performance in organizations. Use of employment interviewing, testing, life-history data, and rating scales for on-the-job behavior. Selection and placement decisions based on test validity and cost-benefit analysis. PREREQUISITES: OS 3103 and MN 3310.

MN 4113 Personnel Training and Development (4-0).
Determination of skills, knowledge, and attitudes in which people should be trained. Identification of who should be trained. Study of methods currently available for training and for evaluating the efficiency of training. PREREQUISITES: MN 3111 or OS 3103 and MN 3310.

MN 4114 Personnel Performance Evaluation (4-0).
Current methods of appraising the performance of individuals in different types of work. Problems associated with each meth-

od. Performance evaluation as a system interfacing with selection, classification, training, advancement, and retention. PREREQUISITES: MN 3111 or OS 3103 and MN 3310.

MN 4115 Personnel Motivation (4-0).
A brief summary of the traditional theories of motivation is given. Several motivation to work theories are discussed along with the research concerning these theories. Current research on the roles of compensation in personnel motivation is considered. PREREQUISITE: MN 3110.

MN 4116 Education and Training (4-2).
This course concentrates on adult learning theory, curriculum design, and instructional technology to help students teach, develop, and supervise curriculum and instruction. The course is especially oriented to the needs of the Human Resource Management community. PREREQUISITE: MN 3105.

MN 4117 Training Requirements Management (4-0).
An introduction to methods, techniques, and value systems for managing the training load in large organizations such as the military services. Models for integrating and analyzing the training loads, personnel inventories, and resource requirements phased over time are examined and evaluated. Factors influencing training needs and tradeoffs in training alternatives for meeting the needs are identified and analyzed. Procedures for programming and budgeting the training requirements are presented. Case studies provide the student the opportunity to apply principles. Additional content may include: instructional system design, R&D in training technology, and training requirements determination in new systems.

MN 4120 Career Transition Management (4-0).
Study of the strategies for "learning the ropes" in entering unfamiliar organizational settings such as changing jobs. Course contains three phases: building theory from experience; reviewing and evaluating, relevant literature; and assessing and recommending improvements in current organizational practices. PREREQUISITES: MN 3105 and consent of Instructor.

MN 4121 Organization Theory (4-0).
Study of the major theories of modern organizations. This course emphasizes the analysis of organizational phenomena from multiple perspectives using theories of individual, group, and organizational behavior. Topics include organization design, management of change, open-systems theory, and contingency theories. PREREQUISITE: MN 3105

MN 4122 Planning and control: Measurement and evaluation (4-0).
Theory and techniques of the managerial functions of planning and control. Emphasis will be placed upon the effects of the planning and control structure on the behavior of human components of the system. Topics will include the problems associated with the utilization of surrogates for measurement purposes; the analysis of the influence of assumptions, values, and objectives on the planning and control process; budgeting and forecasting; performance evaluation and reward structure. PREREQUISITES: MN 3105 and MN 3161.

MN 4123 Organization Development II (4-0).
A study of the field of organization development. The course provides knowledge and skills of organization development and consultative skills to improve organizational effectiveness. The course covers major theories of organization growth and development and a variety of OD strategies designed to improve organizational functions. Students will have opportunities to demonstrate and refine their individual skills in small group settings. PREREQUISITE: MN 3114.

MN 4124 Organization Development III (4-0).
Course provides an opportunity for students to practice organizational development with an actual client organization. Students will gain a thorough understanding of the complexities, strengths, and weaknesses of team O.D. consultation by integrating previously learned theory with practice. PREREQUISITES: MN 3114, MN 4123.

MN 4125 Managing Planned Change in Complex Organizations (4-0).
Examination of the approaches to planning and managing change efforts in complex social systems made up of the interdependent components: technology, structure, task and

people, and of the role of the manager or staff specialist and the process of helping. Emphasis placed on strategies and technologies for diagnosis and planning aimed at effective implementation. Opportunities for practice using both simulations and actual organizational cases. Designed for graduate students interested in the problems involved in effective implementation of technologically, structurally, or human resource-based planned change efforts. PREREQUISITES: MN 3105 and Departmental permission.

MN 4126 Selected Topics in the Behavioral Sciences (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4127 Selected Topics in Organization and Management (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4142 International Trade and Development Policy (4-0).
Leading issues in trade and development policy. Consideration of the implications of alternative economic systems on national policies. PREREQUISITE: MN 3142.

MN 4145 Policy Analysis (4-0).
This course concentrates on analysis of large scale defense resource allocation problems, using cost-effectiveness models. Topics include: discounting, constrained optimization, estimation problems, and efficiency over time. Case studies will be emphasized. PREREQUISITE: MN 3172.

MN 4147 Industrial Relations (4-0).
Development of the institutions and techniques for resolving conflict over wages and conditions of work. Theories of bargaining and arbitration. PREREQUISITE: MN 3101.

MN 4151 Internal Control and Financial Auditing (4-0).
Study of the objectives and techniques of internal control systems and audits of financial records and reports. Specific topics include the independent audit function in America, audit evidence and procedures in general, the auditor's decision process, statistical sampling for auditing, and controls and audit problems in EDP systems. Audits of several transaction cycles are examined. PREREQUISITES: MN 3161, IS 3183, and OS 3103 or the equivalent.

MN 4152 Corporate Financial Management (4-0).
The management of the finance function in industry, with particular attention to defense contractors. Specific topics include cash and working capital management, long-term financing, determination of optimal capital structure, and valuation of a going concern. PREREQUISITE: MN 3161.

MN 4153 Seminar in Accounting and Control (4-0).
Research and discussion of current developments and controversies in accounting and financial controls for government and industry. PREREQUISITES: MN 3161 and permission of Instructor.

MN 4154 Financial Management in the Armed Forces (4-0).
Review of financial management concepts and practices in DOD and the Armed Forces, with emphasis on the Department of the Navy. Includes study of PPBS, controllership, budget formulation and execution, headquarters and field activity accounting systems, and various types of funds. PREREQUISITES: MN 2155 or MN 3161 and MN 3172 or the equivalent.

MN 4155 Operational Auditing in the Public Sector (4-0).
Study of the internal review systems in governments. Examines the function of internal review and the benefits that accrue from a well-organized effort. Specific topics include: staffing, training, organizing and planning internal reviews; conducting preliminary surveys; developing audit programs; conducting field work; drafting reports; follow-up; compliance/attest, efficiency and economy, and program results audits; and review of public sector areas such as internal control, dollarization, budgeting, accounting, maintenance, public works, and purchasing; and public sector audit organizations. Students do case work and a 2-3 week audit project at a government activity. PREREQUISITE: MN 3161.

MN 4159 Accounting Theory and Standards (4-0).
Advanced study of the basic concepts and standards underlying published financial reports. Specific topics include various approaches to the formulation of accounting standards, bases of asset valuation, alternative concepts of earnings, and measurement of equities. Attention is devoted to alternative accounting methods, controversial reporting issues, and prospective future developments. Current accounting standards are evaluated critically in the light of theoretical constructs. PREREQUISITE: MN 3161.

MN 4161 Financial Management Control Systems (4-0).
Study of the structure and the processes of management control in government organizations. Specific topics include the basic concepts of planning and control, organization of the management control function, measurement of inputs and outputs, pricing government services, programming, budgeting, accounting, and performance evaluation. PREREQUISITES: MN 3105 and MN 2155 or MN 3161.

MN 4162 Cost Accounting (4-0).
Review of basic cost concepts and classifications. Study of cost accounting systems, allocation of direct and indirect costs to cost objectives, and special problems of accounting for materials, direct labor, and factory overhead. Special attention is given to the objectives and the substance of Cost Accounting Standards for negotiated defense procurement contracts. PREREQUISITE: MN 3161.

MN 4163 Analytical Techniques for Financial Control and Planning (4-0).
Study of practical application of quantitative methods in planning and controlling cost. Covered are introductions to the relevant quantitative techniques, the conditions for successful application, and data needed for application. The goal is to provide sufficient background for students to apply analytical techniques to various cost control and planning environments in the public sector. PREREQUISITES: MN 3161, OS 3103.

MN 4165 Selected Topics in Accounting and Financial Management (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in accounting and financial management and Departmental approval.

MN 4191 Decision Analysis (4-0).
Discussion of the major topics of decision analysis, including decision theory, single- and multi-attribute utility theory, value of information, and modelling techniques. The course includes exposure to and use of computer models to structure and solve problems. PREREQUISITE: OS 3006.

MN 4192 Workshop in Management Science (2-0 to 5-0).
This course may be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4193 Selected Topics in Management Science (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQQUSITE: Departmental approval.

MN 4225 Labor Law (4-0).
Labor Law as it affects management, labor, and the public with special emphasis on legal problems confronting military personnel in managerial situations. PREREQUISITE: MN 3101.

MN 4302 Public Expenditure, Policy, and Analysis (4-0).
The process of federal government decision-making particularly as reflected in the defense budgeting process. Models of budget decision making, including decentralization. Application of social choice concepts. Application from the defense budgeting process. PREREQUISITES: MN 3161, MN 4145.

MN 4304 Seminar in Systems Acquisition (4-0).
Presentation of a wide selection of topics from current literature and research in systems acquisition. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

MN 4305-4306 Systems Engineering Management I-II (4-0).
The objective of these courses is to provide the students with the opportunity to study real-world Navy project management decision-making. It covers technical management as applied to the systems acquisition process and stresses systems engineering disciplines and their life cycle integration with emphasis on performance, cost and schedule trade-offs. The course is conducted by means of lectures and readings on sys-

tems engineering and the systems engineering disciplines, in-depth study of life-cycle management of selected Navy projects by teams of students and participation in the Defense Management Simulations (DMS) exercise. PREREQUISITES: MN 3301, MN 3305, MN 3309, OS 3301.

MN 4308 Advanced Systems Engineering (4-0).
This course provides students with the opportunity to study the life cycle development of a selected Navy system. The students analyze the systems engineering decisions made in terms of system requirements, performance capability, operational readiness, system effectiveness, reliability, and maintainability design trade-offs. PREREQUISITES: MN 3308, MN 3309, OS 3301.

MN 4310 Logistics Engineering (4-0).
Development of the maintenance concept. Functional analysis. Logistics support analysis including life cycle costing. Design for support. Test and evaluation. Production. Provisioning and resupply. PREREQUISITES: OS 3102, OS 3103, OS 3006, or the equivalent.

MN 4371 Acquisition and Contracting Policy (4-0).
Seminar utilizing case study appraisals of Government and business acquisition/contracting policies. Emphasis is on acquisition/contracting decision-making and policy formulation. PREREQUISITES: MN 3305 or MN 3371 and permission of Instructor.

MN 4372 Seminar in Acquisition and Contracting Management (4-0).
Development, presentation, and discussion of a wide selection of topics from current issues and research in acquisition and contracting. PREREQUISITE: MN 3305 or permission of Instructor.

MN 4373 Transportation Policy (4-0).
Advanced study in the management of transportation systems. Emphasis on coordinated transportation management in large-scale systems and its implication for DOD. PREREQUISITE: MN 3373.

MN 4376 Seminar in Material Logistics (4-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4650 The Military Health Care Delivery Systems (4-0).
This course is designed to acquaint the student with the structure and operation of the Department of Defense's system for providing health care to those eligible under current regulations; to identify current problem areas, and through application of systems analysis and management techniques to address the possible solutions to these problems in a course project. PREREQUISITE: MN 3650.

MN 4651 Hospital Economics and Systems Analysis (4-0).
This course deals analytically and empirically with the major organizational and economic structures and problems associated with the operation of a health care delivery facility or group of facilities (e.g., hospitals or integrated groups of clinics). The roles of institutional incentives, methods of reimbursement, provider organization and payment, and exogenous factors such as general inflation and legislative parameters are discussed. The objective is a working background knowledge of these major elements in the health care production process and probable systemic change. PREREQUISITES: MN 3140 and MN 3650.

MN 4652 Micro Health Systems Analysis (4-0).
The purpose of this course is to analyze in-depth, using analyses of extant institutional constructs, the potential for deriving policy recommendations and designing research to motivate more efficient provision of health care by individual facilities. The emphasis will be on identifying gaps in incentives and organizational structures which lead to suboptimal facility behavior in the cost containment and quality areas. PREREQUISITES: MN 3140, MN 3650, MN 4650 and MN 4651.

MN 4761 Manpower Economics II (4-0).
This course is designed to acquaint the student with human capital theory and to explore its relevance within the military. Included will be studies on the costs and benefits of investments in training both from the military's and the individual's point of view. The components of general and specific training will be reviewed and applied to the military. The institutional, social and economic considerations which affect human capital investments will be studied (including collective bargaining, discrimination, fringe benefits). PREREQUISITE: MN 3760.

MN 4920 Public Expenditure Analysis (4-0).
A presentation of basic concepts such as public goods, joint production, and externalities which necessitate governmental market intervention. Techniques to analyze the effects and desirability of particular government expenditures are covered and include the theory of second best, cost-benefit analysis, consumer surplus, and social discounting. PREREQUISITE: MN 3172 or AS 3611.

MN 4942 The Structure, Conduct, and Performances of the Defense Industries (4-0).
A study of selected defense industries structure (e.g., seller concentration, product differentiation, barriers to entry, demand for products, buyer concentration), conduct (e.g., pricing policy, product characteristics policy, policies toward rivals, policies toward customers), and performance (e.g., efficiency, progress, employment). The government as consumer and regulator. Typical industries covered are aerospace, computers, shipbuilding, and telecommunications. PREREQUISITE: Microeconomics (MN 3140 or AS 3610).

MN 4945 Selected Topics in Economics (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in economics and Departmental approval.

Mn 4950 Workshop in Management (2-0 to 5-0).
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

MN 4960 Readings in Management (2-0 to 5-0).
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

MN 4970 Seminar in Management (2-0 to 5-0).
Content of course varies. Students will be allowed credit for taking this course more than one time. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

Admiral Thomas B. Hayward, Chief of Naval Operations, visits the Postgraduate School

DEPARTMENT OF AERONAUTICS

Students preparing model for wind tunnel tests

Max Franz Platzer, Professor of Aeronautics; Chairman (1970)*; Dipl Ing., Tech. Univ. of Vienna, Austria, 1957; Dr. Techn. Sci., 1964.

Robert Edwin Ball, Professor of Aeronautics (1967); B.S. in C.E., Northwestern Univ., 1958; M.S., 1959; Ph.D., 1962.

Richard William Bell, Professor of Aeronautics; (1951); A.B., Oberlin College, 1939; Ae.E., California Institute of Technology, 1941; Ph.D., 1958.

Oscar Biblarz, Associate Professor of Aeronautics (1968); B.S., Univ. of California at Los Angeles, 1959; M.S., 1963; Ph.D., Stanford Univ., 1968.

Daniel Joseph Collins, Professor of Aeronautics (1967); B.A., Lehigh Univ., 1954; M.S. in M.E., California Institute of Technology, 1955; Ph.D., 1961.

Allen Eugene Fuhs, Distinguished Professor of Aeronautics (1966); B.S.M.E., Univ. of New Mexico, 1951; M.S.M.E., California Institute of Technology, 1955; Ph.D., 1958.

Theodore Henry Gawain, Professor of Aeronautics (1951); B.S., Univ. of Pennsylvania, 1940; D.Sc., Massachusetts Institute of Technology, 1944.

Charles Horace Kahr, Jr., Professor of Aeronautics (1947); B.S., Univ. of Michigan, 1944; M.S., 1945.

Donald Merrill Layton, Professor of Aeronautics (1965); B.S., U.S. Naval Academy, 1945; B.S.A.E., Naval Postgraduate School, 1953; M.S. in A.E., Princeton Univ., 1954; M.S. in Management, Naval Postgraduate School, 1968.

Gerald Herbert Lindsey, Professor of Aeronautics (1965); B.E.S. in M.E., Brigham Young Univ., 1960; M.S. 1962; Ph.D., California Institute of Technology, 1966.

James Avery Miller, Associate Professor of Aeronautics (1963); B.S. in M.E., Stanford Univ., 1955; M.S. in M.E., 1957; Ph.D., Illinois Institute of Technology, 1963.

David Willis Netzer, Professor of Aeronautics, (1968); B.S.M.E., Virginia Polytechnic Institute, 1960; M.S.M.E., Purdue Univ., 1962; Ph.D., 1968.

Louis Vincent Schmidt, Professor of Aeronautics, (1964); B.S., California Institute of Technology, 1946; M.S., 1948; Ae.E., 1950; Ph.D., 1963.

Raymond Parmous Shreeve, Director, Turbopropulsion Laboratory, and Adjunct Professor of Aeronautics (1971); B.Sc., Imperial College, London, 1958; M.S.E., Princeton Univ., 1961; Ph.D., Univ. of Washington, 1970.

Robert Diefendorf Zucker, Associate Professor of Aeronautics (1965); B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

Emeritus Faculty

Wendell Marios Coates, Distinguished Professor Emeritus (1931); A.B., Williams College, 1919; M.S., Univ. of Michigan, 1923; D.Sc., 1929.

Ulrich Haupt, Associate Professor Emeritus (1954); Dipl. Ing., Institute of Technology, Darmstadt, 1934.

George Judson Higgins, Professor Emeritus (1942); B.S., In Eng. (Ae.E.), Univ. of Michigan, 1923; Ae.E., 1934.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN AERONAUTICAL ENGINEERING

The following are academic requirements for the award of degrees as determined by the Department of Aeronautics. In addition, the general minimum requirements as determined by the Academic Council must also be satisfied.

The entrance requirement for study in the Department of Aeronautics generally is a baccalaureate in engineering earned with above average academic performance. This requirement can sometimes be waived for students who have shown distinctly superior ability in backgrounds other than engineering but who have had adequate coverage in the basic physical and mathematical sciences. All entrants must obtain the approval of the Chairman, Department of Aeronautics.

Students who have not majored in Aeronautics, or who have experienced a significant lapse in continuity with previous academic work, initially will take preparatory courses in aeronautical engineering and mathematics at the upper division level, extending through the first two to three academic quarters and constituting a portion of the coursework for degrees in Aeronautics. Final approval of programs leading to degrees in Aeronautical Engineering must be obtained from the Chairman, Department of Aeronautics.

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

Upon completing the preparatory courses, students may be selected on the basis of academic performance for the degree program leading to the Master of Science in Aeronautical Engineering. However, students who have recently earned a degree with major in Aeronautics may apply for admission directly to the graduate program.

The Master of Science degree requires a minimum of 36 credit hours of graduate courses, of which at least 20 credit hours shall be at the 4000 level. It also requires that not less than 32 credit hours shall be in the disciplines of engineering, physical science or mathematics, and that this shall include a minimum of 20 hours of courses in the Department of Aeronautics and a minimum of 8 hours in other departments.

An acceptable thesis is required for the degree unless waived by the Chairman, Department of Aeronautics, in which case 10 quarter hours of 4000 level courses in the disciplines of engineering, physical science, or mathematics will be required in addition to those specified above, increasing the total requirement to 46 quarter hours of graduate level credits.

AERONAUTICAL ENGINEER

Upon completing the preparatory courses, students may be selected on the basis of academic performance for the program leading to the degree Aeronautical Engineer. Selection to this degree program shall be limited to those students who, in the opinion of the faculty, have the potential to conduct the required research. The degree Aeronautical Engineer requires a minimum of 72 credit hours of graduate courses, of which at least 48 credit hours shall be at the 4000 level. It also requires that not less than 64 credit hours shall be in the disciplines of engineering, physical science, or mathematics, and that this shall include a minimum of 36 hours of courses in the Department of Aeronautics and a minimum of 12 hours in other departments. An acceptable thesis is required for the degree.

Students admitted to work for the degree Aeronautical Engineer may be satisfying requirements for the Master of Science degree concurrently. The Master of Science in Aeronautical Engineering may be conferred at the time of completion of the requirements for that degree.

DOCTOR OF PHILOSOPHY AND DOCTOR OF ENGINEERING

The Department of Aeronautics offers programs leading to the doctorate in the fields of gasdynamics, flight structures, flight dynamics, propulsion, aerospace physics, and aerospace vehicle design.

Entrance into the doctoral program may be requested by officers currently enrolled who have sufficiently high standing. The Department of Aeronautics also accepts officer students selected in the Navy-wide Doctoral Study Program, and civilian students selected from employees of the United States federal government.

All applicants who are not already enrolled as students in the Department of Aeronautics shall submit transcripts of their previous academic and professional records and letters of recommendation to the Department Chairman. The Chairman, with the advice of other department members, shall decide whether to admit the applicant to the Doctoral Program.

Every applicant who is accepted for the Doctoral Program will initially be enrolled in the AeE Program under a special option which satisfies the broad departmental requirements for the Engineer's degree and which includes research work. As soon as feasible, the student must find a faculty advisor to supervise his research and help him initially in the formulation of his plans for advanced study. As early as practicable thereafter, a Doctoral Committee shall be appointed to oversee that student's individual Doctoral Program as provided in the school-wide requirements for the Doctor's degree.

A noteworthy feature of the program leading to the Doctor of Engineering degree is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the federal government. The degree requirements are outlined in general school requirements for the Doctor's degree.

In the event that a student is unable finally to satisfy the above requirements for the doctorate for any reason but has in the course of his doctoral studies actually completed all of the requirements for the degree of Aeronautical Engineer, he shall be awarded the latter degree.

AERONAUTICAL LABORATORIES

Five major laboratory divisions support instructional and research programs in subsonic aerodynamics, gas dynamics, rocket and ramjet propulsion, turbomachinery, and structures.

The subsonic aerodynamics laboratory consists of two low-speed, continuous flow wind tunnels and a large continuous flow visualization tunnel. Standard techniques are used in the 32 x 45 inch and 42 x 60 inch wind tunnels to study basic fluid flow about bodies, stability and control of flight vehicles, and unsteady flows about bluff bodies and lifting surfaces. Helium bubble filaments are used in the 5 x 5 x 12 foot test section in the three-dimensional flow visualization tunnel to define flow fields of interest, e.g. about helicopter blades, and jet-flap flow.

The gas dynamics laboratory includes a 4 x 4 inch blowdown supersonic wind tunnel, a cold-driven, three-inch double-diaphragm shock tube, and a 2 x 2 x 18 foot open-circuit oscillating flow wind tunnel. Laser interferometers, schlieren systems, hotwire and laser doppler anemometers are used for flow observations. Ruby, He-Ne, argon and CO_2 lasers are available; extensive use is made of laser holography. An electrohydrodynamic research facility permits studies of electric power generation and turbulence. A coaxial plasma accelerator has recently been comppleted.

The rocket laboratory consists of an instrumented control room, a propellant chemistry laboratory, a high pressure air facility, and three test cells. The test cells are equipped for investigating solid, liquid, gaseous, and hybrid rocket combustion. A solid fuel ramjet test facility is also in operation.

The turbopropulsion laboratory houses advanced facilities for engine and engine component research and development in a complex of especially designed concrete structures. One building, powered by a 750 HP compressor, contains a 10″ by 60″ rectilinear cascade wind-tunnel and a large three-stage axial research compressor for low-speed studies. A second building, plant, contains fully instrumented transonic turbine and compressor test rigs in explosion proof test cells. A spin-pit for structural testing of rotors to 50,000 rpm and 1800^{0}F is provided. Model experiments and equipment for instrumentation development are located in a separate laboratory. Data acquisition from 400 channels of steady-state and 16 channels of non-steady measurements at up to 100 kHZ is controlled by the laboratory's HP 21 MX computer system. On-line reduction and presentation of data and multiple-user operation under time sharing are available.

The structural test laboratory contains testing machines for static and dynamic tests of materials and structures, and an electro-hydraulic closed-loop machine for fatigue testing. Aircraft components as large as complete aircraft wings are accommodated on a special loading floor, where static and vibration tests are conducted. A well-equipped dynamics laboratory contains shaker tables, analog computers, and associated instrumentation. An adjacent strain gage and photo-elastic laboratory provides support to test programs and instruction in structural testing techniques.

In addition to the major laboratory facilities, which include extensive instrumentation and data processing capabilities, the department possesses an IBM Series 1 computer with several input/output terminals and graphic/plotting displays. Other research facilities include ballistic ranges for studies of topics such as aircraft vulnerability, a number of flight simulators used with hybrid computers for studying pilot/control system interactions, and a three-ton surface-effect ship. The department also uses a leased aircraft for an in-flight laboratory.

DEPARTMENTAL COURSE OFFERINGS

AERONAUTICS

AE 0010 Aeronautical Engineering Seminar (0-1).
Oral presentations of material not covered in formal courses. Topics cover a wide spectrum of subjects ranging from reports of current research to survey treatments of fields of scientific and engineering interest.

AE 0020 Aeronautical Engineering Program Planning (0-1).
Oral presentations by the Aeronautics Academic Associate and faculty members involved in research with Aeronautical students on program planning, thesis requirements and research specialty areas. The course is given to all students during their second or third quarter on board.

AE 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

A number of preparatory courses in Aeronautics are available through the Continuing Education Division. These one-credit hour mini-courses have been prepared in a self-instructional mode (PSI) and complete descriptions for each mini-course may be found in the Continuing Education catalog. The mini-courses are equivalent to, and may be substituted for, the on-campus courses as follows:

Campus Course	*Equivalent mini-course sequence*
AE 2025	AE 2101 through 2106
AE 2035	AE 2301 through 2304
AE 2045	AE 2401 through 2406

AE 2015 Engineering Dynamics (3-2).
Fundamental physical concepts; dynamics of particles and of systems of particles; concepts of work-energy and impulse-momentum; rigid body dynamics; the inertia tensor and Euler's equations in two dimensions. Introduction to vibration theory.

AE 2025 Introduction to Flight Structures (5-2).
Reviews basic principles of statics. Introduction to concepts of stress and strain, and mechanical behavior of materials. Bending and torsional stress and deflection analysis of representative aero-structural components, including statically indeterminate cases. Introduction to stability analysis, and energy methods. *(May be taken through Continuing Education as mini-courses AE 2101-06.)*

AE 2035 Basic Aerodynamics (3-2).
Dimensional analysis, elements of two-dimensional ideal fluid flow, Kutta-Joukowski law, thin-airfoil theory, finite-wing theory. *(May be taken through Continuing Education as mini-courses AE 2301-04.)*

AE 2036 Performance and Stability (3-2).
Model atmosphere; defined airspeeds; aircraft performance including climb, range, endurance and energy management; principles of longitudinal, lateral and directional static stability of aircraft.

AE 2045 Fundamentals of Thermo-Gasdynamics (5-2).
Properties of fluids. Principles of continuity, momentum, and energy for incompressible and compressible fluids; control volume formulations. Second law of thermodynamics, entropy and irreversibilities; equations of state, properties of pure substances; power cycles. Viscous flows, boundary layer concepts. Compressible flows, adiabatic/isentropic flow; normal shocks, moving and oblique shocks, Prandtl-Meyer flow. *(May be taken through Continuing Education as mini-courses AE 2401-06.)*

AE 2811 Aeronautical Laboratories I (0-2).
A six-week course containing selected experiments in aero-structures to support the material taught in AE 2025. PREREQUISITE: AE 2025. *Graded on Pass/Fail basis only.*

AE 2812 Aeronautical Laboratories II (0-2).
A six-week course containing selected experiments in dynamics to support the material taught in AE 2015. PREREQUISITE: AE 2015. *Graded on Pass/Fail basis only.*

AE 2813 Aeronautical Laboratories III (0-2).
A six-week course containing selected experiments in aerodynamics to support the material taught in AE 2035 and AE 2036. PREREQUISITES: AE 2035, 2036. *Graded on Pass/Fail basis only.*

AE 2814 Aeronautical Laboratories IV (0-2).
A six-week course containing selected experiments in gas dynamics to support the material taught in AE 2045. Includes a tour of the wind-tunnel facilities at NASA-Ames. PREREQUISITE: AE 2045. *Graded on Pass/Fail basis only.*

Upper Division or Graduate Courses

AE 3001 Aircraft Energy Conservation (4-0).
The aim of this course is to provide information on how squadrons can obtain more flight hours from the same amount of fuel. The course includes case studies, minor technical modifications to aircraft, operations planning, sources of fuel loss, and influence of weather. In addition, techniques for fuel conservation as used by commercial airlines and allied air forces will be discussed. The course is intended for (but not restricted to) 1500 officers, whether in an engineering major or not.

AE 3004 Trends in Naval Weapons (4-0).
This course is intended for nonengineering/nonscience majors as well as those engineering and science students who want a one quarter course giving an overall perspective on future naval weapons. The course is mainly a nontechnical condensation of material from AE 4701 Missile Engineering, AE 4705 Guns, Mines, and Torpedoes, AE 4706 High Energy Laser System Design, AE 4707 Weapon Systems Design and Integration. Additional topics are discussed as appropriate.

AE 3005 Survey of Aircraft & Missile Technology: Concepts and Applications (4-0).
(For Non-Aeronautical Engineering Students) A survey of aeronautical engineering concepts as applied to airplanes and missiles, starting with explanations of the basic principles of aerodynamics, performance, propulsion, etc., and extending to examples of these principles in present-day hardware.

AE 3201 System Safety Management and Engineering (3-2).
An introduction to System Safety, with emphasis on the requirements imposed by MIL-STD-882A. Fundamental mathematical concepts (probabilities, distribution theory, Boolean algebra); safety analysis techniques (hazard analysis, fault-tree analysis, sneak circuit analysis); safety criteria, tasks, data, and documentation; lifecycle considerations.

AE 3251 Aircraft Combat Survivability (3-2).
This course brings together all of the essential ingredients in a study of the survivability of fixed wing, rotary wing and missile aircraft in a hostile (non-nuclear) environment. The technology for increasing survivability and the methodology for assessing the probability of survival in a AAA/SAM environment are presented in some detail. Topics to be covered include: current and future threat descriptions; the mission/threat analysis; combat data analysis of SEA and Mid-East losses; vulnerability reduction techniques and technology for the major aircraft systems; susceptibility reduction concepts and equipment for reducing the probability of detection and avoidance of the threat; and vulnerability, susceptibility and survivability assessment and trade-off methodology. In-depth studies of the survivability of several fixed wing and rotary wing aircraft will be presented. PREREQUISITE: U.S. Citizenship and SECRET clearance.

AE 3304 Rotary Wing Aircraft Technology (4-0).
(For Non-Aeronautical Engineering Students) A course designed to familiarize the student with the major aerodynamic, propulsion, structural, and stability and control aspects of rotary wing aircraft, past and current helicopter developments, technology status and problems. PREREQUISITE: Consent of Instructor.

AE 3305 V/STOL Aircraft Technology (4-0).
(For Non-Aeronautical Engineering students) Basic aerodynamic and propulsion principles and phenomena, past and current vertical take-off and landing aircraft developments, current technology status and problems. U.S. Navy V/STOL aircraft requirements and acquisition programs. Russian V/STOL aircraft and assessment of USSR-V/STOL aircraft technology and trends, impact of V/STOL aircraft technology on naval systems acquisition and operations. PREREQUISITE: Consent of Instructor.

AE 3815 Advanced Aeronautical Laboratories (0-3).
Selected experiments emphasizing modern instrumentation techniques in the areas of gas dynamics, propulsion, structures, and flight dynamics. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 3900 Special Topics in Aeronautics (Variable credit up to five hours.)
Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Department Chairman.

Graduate Courses

AE 4101 Flight Vehicle Structural Analysis (3-2).
Graduate core course in structures covering basic definitions and field equations for solid bodies, two-dimensional stress and analysis, thin skin and thick skin wing bending analysis, fracture and fatigue theory. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4102 Advanced Aircraft/Missile Structural Analysis (3-2).
The finite element method of structural analysis will be studied and applied to aircraft and missile structures. Capabilities of the current finite element computer programs will be discussed. An introduction to the theory of structural dynamics and stability will also be presented. PREREQUISITE: AE 4101.

AE 4103 Advanced Aircraft Construction (3-2).
A course covering the manufacturing techniques and analysis of composite materials and sandwich construction. Theories of failure, damage and repair. Advanced design concepts. PREREQUISITE: AE 4101.

AE 4273 Aircraft Design (3-2)
Complex engineering design problems in the field of flight vehicles are presented for solution to develop a basic understanding of the design process. This course in aircraft synthesis draws upon all of the disciplines of aeronautics to produce conceptual aircraft designs through projects which are formulated individually by each student to meet given specifications. PREREQUISITE: Completion of the Aero Graduate Core.

AE 4301 Stability and Control of Aerospace Systems (3-2).
Equations of motion, stability derivatives; short period, phugoid, roll, spiral and Dutch roll modes. Transfer functions, Bode plots. Connections with static stability and handling quality criteria. Linear feedback systems, Root locus method, synthesis criteria; relation between time and frequency domain. Analysis of airplane plus pilot, synthesis of stability augmentation systems, autopilot loop synthesis. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4304 Helicopter Performance (3-2).
The performance characteristics of rotary wing aircraft. Blade motion, momemtum theory, blade element theory, tip loss factor, ground effect, hover, vertical flight, forward flight, climbing flight, autorotation, tail rotors, range and endurance, and multiple rotors. Numerical problems in helicopter performance. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4305 V/STOL Aircraft Technology (3-2).
Types of V/STOL aircraft, fundamental principles, main performance characteristics, and propulsion requirements, STOL technology: mechanical high-lift devices, powered-lift devices, jet flaps, augmentor wings; VTOL technology: flow vectoring devices, lift engine and lift fan technology, augmentor wings; airframe/propulsion system interactions, ground interference effects: V/STOL stability and control considerations, handling qualities; review of current development programs, NAVY V/STOL requirements and programs. PREREQUISITE: Aero Graduate Core or permission of Instructor.

AE 4310 Status, Trends and Uncertainties in Aerospace Vehicle Design. (4-0).
Critical analysis of current analytical and testing methods used to design flight vehicles and air weapons. Emphasis is placed on weaknesses in underlying assumptions and inherent uncertainties caused by limited

analysis and testing capability available during a typical development program. PREREQUISITE: Aero Graduate Core or permission of Instructor.

AE 4318 Aeroelasticity (4-0).
Response of discrete and continuous elastic structures to transient loads and to steady oscillatory loads, utilizing matrix methods. Static aeroelasticity problems in aircraft, non-stationary airfoil theory. Application to the flutter problem. Transient loads, gusts, buffet, and stall flutter. PREREQUISITE: AE 4301.

AE 4323 Flight Evaluation Techniques (3-2).
Quantitative and qualitative techniques for the evaluation of aircraft performance and handling qualities of flight; aircraft data acquisition systems; normalizing and standardizing of flight test data; pilot rating scales; effects of design parameters; application of specifications to flight evaluations. In-flight laboratory is provided. PREREQUISITE: AE 4301 or equivalent.

AE 4342 Advanced Control for Aerospace Systems (3-2).
State variable analysis including state variable feedback and state variable estimators (observers). Optimal control; digital fly-by-wire systems. Topics from non-linear systems and/or stochastic control. PREREQUISITE: AE 4301.

AE 4343 Guided Weapon Control Systems (3-2).
Detailed analysis of tactical missiles, performance of target trackers, basic aerodynamics of missiles, missile autopilot design, missile servos and instruments, line of sight guidance loops, terminal guidance, proportional navigation. PREREQUISITE: AE 4301 or equivalent.

AE 4431 Aerothermodynamics & Design of Turbomachines (3-3).
Flow and energy exchange in compressors and turbines, and current engineering methods for their aerodynamic design, test, and measurement. PREREQUISITE: AE 4451 or consent of Instructor.

AE 4451 Aircraft and Missile Propulsion (3-2).
Description, design criteria, analysis and performance of solid propellant rockets, ramjets, turboprops, turbojets, and turbofans. Analysis of components: inlets, compressors, combustors, turbines and nozzles. Current state-of-the-art and impact of trends in propulsion technology. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4452 Rocket and Missile Propulsion (4-0).
Applications and analysis of propulsion devices for tactical weapons systems. Systems considerations and trade-offs. Introduction to multi-stage rockets. Combustion temperature, product composition, kinetics, smoke, detonation sensitivity, pollution. Review of current exploratory development programs. PREREQUISITE: AE 4451.

AE 4501 Current Aerodynamic Analysis (3-2).
Introduction to current aerodynamic analysis methods for subsonic and supersonic flight vehicles. Developments proceed from the three-dimensional Navier-Stokes equations to various approximation methods, such as linearized, inviscid subsonic and supersonic panel methods for wing-body combinations; discussion of sweep-back effect and area rule; laminar and turbulent boundary layer analysis; use of state-of-the-art computer programs. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4502 High-Speed Aerodynamics (4-0).
Topics include linearized surface theory for subsonic and supersonic aircraft in both steady and unsteady motion, nonlinear transonic and supersonic flow theory and solutions by characteristics, relaxation and timemarching methods; boundary layer computations, shock-boundary layer interactions and separated flow effects. Applications include the discussion of supercritical airfoils, controlled vortex lift, blended wing-body designs, etc., on aircraft performance. Also, selected internal flow problems are discussed. PREREQUISITE: AE 4501.

AE 4503 Missile Aerodynamics (4-0).
The aerodynamics of missiles and guided projectiles for various speed regimes and motions. Topics include slender body and linearized theory as well as nonlinear aerodynamic effects, coupling effects, Magnus effects, etc. The impact of these effects on missile flight dynamics, guidance and control is included. PREREQUISITE: AE 4501.

AE 4504 Convective Heat and Mass Transfer (4-0).
Convective heat and mass transfer on internal and external flow systems common to aerospace vehicles; laminar and turbulent flows. Analytic techniques, integral and numerical methods, experimental correlations. Effects of variations in thermophysical properties. PREREQUISITE: AE 4501.

AE 4505 Laser/Particle Beam Technology (3-2).
Survey of different types of lasers, including gaseous, solid state, gasdynamic and chemical lasers, electron beams; resonator cavities for lasers and external propagation mechanisms; high energy lasers and charged particle beams, military applications. PREREQUISITE: Consent of Instructor.

AE 4632 Computer Methods in Aeronautics (3-2).
Use of the digital computer in numerical methods. Classification of Aeronautical Engineering problems as equilibrium, eigenvalue or propagation problems. Computer solution procedures developed for the ordinary and partial differential equations of gas dynamics, heat transfer, flight mechanics and structures. PREREQUISITE: Aero Preparatory Phase or equivalent.

AE 4641 Aeronautical Data Systems (3-2).
A design-project-oriented course utilizing microprocessor technology with emphasis upon aeronautical engineering applications. Both software and hardware aspects of system integration will be considered for engineering tradeoffs during problem definition and solution. PREREQUISITE: EE 2810 or equivalent.

AE 4900 Advanced Study in Aeronautics (Variable credit up to five hours.)
Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Department Chairman.

WEAPONS ENGINEERING COURSES

Upper Division or Graduate Courses

AE 3701 Missile Aerodynamics (3-2).
Compressible flows, adiabatic/isentropic varying-area flow, normal and oblique shocks, Prandtl-Meyer flow, Fanno and Rayleigh flows. Potential flow, thin-airfoil and finite wing theories. Linearized equations, Ackeret theory, Prandtl-Glauert transformations for subsonic and supersonic wings. Planform effects. Flow about slender bodies of revolution, viscous cross-flow theory, the area rule. PREREQUISITES: PH 3161, CH 2401, PH 3152 or equivalents.

AE 3702 Introduction to Space Warfare (4-0).
The role of USN and DoD in space will increase in coming years. The course provides an overview of projected space technologies, possible weapons for space (e.g., lasers), need for a manned space operational center, hypothetical scenarios for space operations, requirements for future space transportation systems, and joint civil and military programs. In addition to the descriptive material, the course includes technical introduction to orbital mechanics, launch vehicle propulsion, and aerothermodynamics. PREREQUISITES: U.S. citizenship, SECRET clearance, and consent of Instructor.

AE 3705 Warheads and Lethality (3-2).
This course examines the design and the effectiveness of missile warheads for use against air targets. The generation of the damage mechanisms, such as blast, fragments, and incendiary particles, is studied for several types of warheads. The functions of fuzes and their modes of operation for target sensing is also discussed. The vulnerability of the target to the damage mechanisms is examined, and the procedures for assessing the measures of target vulnerability are described. The assessment of the effectiveness of the warhead, as measured by the probability of target kill given a detonation, is made in the Endgame analysis. Total missile lethality is evaluated by determining the probability of target kill, given a single missile launch. Target countermeasures for reducing the missile lethality are also described.

Graduate Courses

AE 4701 Missile Engineering (4-0).
Aim of course is to provide a technical overview of shipboard-based tactical missiles and submarine-based strategic missiles, ICBM and cruise missiles. Missile trajectories. Propulsion; rocket, ramjet, and ordnance turbojets. Missile aerodynamics. Guidance and control. Reentry phenomena. Missile design features; mission range, lethality, maneuverability, Mach number and payload. Missile examples: AEGIS, Poseidon, Trident, MX. PREREQUISITE: Completion of an Engineering/Science Core or equivalent.

AE 4702 Missile Propulsion and Performance (4-1).
Design fundamentals, systems calculations, and current technology for existing and proposed propulsion devices used for missiles. Utilizing measured lift and drag characteristics (subsonic, transonic, supersonic), calculations of performance for cruise missiles, long- and short-range tactical missiles: maximum acceleration, speed, climb, ceiling, range, and agility in maneuvering trajectories. PREREQUISITES: AE 3701, and CH 2404.

AE 4703 Missile Stability, Guidance and Control (3-2).
Static and dynamic stability and control. Neutral point, control effectiveness, trim in maneuvering flight. Configuration determinants (canard, aft-tail; interior arrangement). Dynamic modes. Design criteria for instrumentation and automatic control. Guidance loops: line-of-sight, homing and proportional guidance. Miss distance analysis. Modern control theory applications. PREREQUISITES: AE 4702, and EE 2411.

AE 4704 Missile Configuration and Design (3-2).
A project oriented course centering on the design of a missile by each student. Principles of aerodynamics, guidance, control, propulsion, and structures will be used to synthesize a missile to respond to a specified threat. PREREQUISITE: AE 4703 or completion of the Aero Graduate Core.

AE 4705 Guns, Mines, and Torpedoes (4-0).
Gun internal ballistics; gun propellant combustion, one-dimensional unsteady model of gas flow. External ballistics: Flat-earth trajectory equations with aerodynamic forces and/or propulsion. Guided projectiles. Fire control. Damage by blast in air and water. Mines; sensors and firing logic; mine detection and neutralization. Torpedoes; hydrodynamic drag, propulsion, warheads. PREREQUISITE: Completion of an Engineering/Science Core or equivalent.

AE 4706 High Energy Laser System Design (4-0).
Types of lasers including excimer lasers. Laser performance. Adaptive optics. Propagation of laser beams. Pointing and tracking. Acquisition and handoff. Fire control. Damage mechanisms. Advantages and limitations of both CW and Pulsed. Applications. Students design a complete laser system. PREREQUISITE: Completion of an Engineering/Science Core or equivalent.

AE 4707 Weapons Systems Design and Integration (4-0).
Weapons-suite platform interactions; weapon performance; kill probabilities; threat models; target data acquisition and processing; weapons computer modelling; elements of ship vulnerability; weapon suite reaction time, deterministic and probabilistic; interaction of several weapons suites; degraded weapons performance of damaged ship. Student selects/designs a weapons suite to counter a specific threat. Design includes layout and reaction times. PREREQUISITE: Completion of an Engineering/Science Core or equivalent.

ANTISUBMARINE WARFARE

ASW asset, USS MCINERNEY (FFG-8)

The Antisubmarine Warfare Academic Group has administrative responsibility for the academic content of the Antisubmarine Warfare Program. Teaching in this program is carried out by faculty members attached to the various Academic Departments associated with the Program.

Robert Neagle Forrest, Professor of Operations Research; Chairman (1964)*; B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

Robert Hathaway Bourke, Associ- Professor of Oceanography (1971); B.S., U.S. Naval Academy, 1961; M.S., Naval Postgraduate School, 1968; M.A., Stanford Univ., 1971.

Donald Charles Daniel, Associate Professor of Political Science (1975); B.A., Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

John Norvell Dyer, Professor of Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

Carl Russell Jones, Professor of Administrative Sciences (1965); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

George Lawrence Sackman, Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D., Stanford Univ., 1964.

Alan Robert Washburn, Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

Carroll Orville Wilde, Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

Oscar Bryan Wilson, Jr., Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

**The year of joining the Postgraduate School faculty is indicated in parenthesis.*

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

1. The degree of Master of Science in Systems Technology will be awarded at the completion of an interdisciplinary program carried out in accordance with the following degree requirements:

    a. The Master of Science in Systems Technology requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four disciplines must be included and in three disciplines, a course at the 4000 level must be included.
    b. An approved sequence of at least three courses constituting advanced specialization in option area must be included.
    c. In addition to the 45 hours of course credit, an acceptable group project or thesis must be completed.
    d. The program must be approved by the Chairman of the ASW Group.

DEPARTMENTAL COURSE OFFERINGS

ST 0001 Seminar (0-1).
Special Lectures, and discussion of matters related to the ASW Program. PREREQUISITE: SECRET clearance.

ST 0810 Thesis Research/Group Project (0-0).
Students in the Systems Technology curricula will enroll in this course which consists of an individual thesis or a group project involving several students and faculty.

ST 1810 Introduction to Programmable Calculators (4-1).
Programming and use of keyboard functions, data storage and retrieval, printers, plotters, subroutine packages. This course is designed for students in the Antisubmarine Warfare and Weapons Engineering curricula. *Graded on Pass/Fail basis only.*

Upper Division or Graduate Course

ST 3000 Study Project On ASW Systems Performance (0-2).
This project is the study and analysis of the performance of an assigned type of ASW system under a variety of realistic operating conditions. PREREQUISITE: Enrollment in ASW curriculum or consent of curriculum coordinator, and SECRET clearance. *Graded on a Pass/Fail basis only.*

Graduate Course

ST 4999 Special Studies in ASW (1-0 to 4-0).
A course designed to meet the needs of students for special work in advanced topics related to ASW.

AVIATION SAFETY PROGRAMS

Discussing high-technology helicopter airfoil

Robert Lewis, Captain, U.S. Navy; Director (1978)*; B.A., Naval Postgraduate School, 1966; M.A., George Washington Univ., 1975; Ed.S., 1977.

David Lee Albritton, Commander, U.S. Navy; Instructor in Aviation Safety Command Course and Accident Reporting and Investigation (1980); B.S., Naval Postgraduate School, 1971.

Milton Harold Bank, II, Associate Professor of Aeronautical Eng. and Safety (1971); B.S., U.S. Naval Academy, 1957; B.S.A.E., Naval Postgraduate School, 1964; Engr., Stanford Univ., 1967; M.S., Georgia Institute of Technology, 1970; Ph.D., 1971.

Russell Branson Bomberger, Professor of Law and Psychology (1958); B.S., Temple Univ., 1955; Ll.B., LaSalle Univ., 1968; J.D., 1969; M.A., Univ. of Iowa, 1956; M.S., Univ. of Southern California, 1960; M.A., Univ. of Iowa, 1961; Ph.D., 1962.

John Paul Cress, Major, U.S. Marine Corps; Instructor in Aeronautical Engineering and Safety (1978); B.S.A.E., Ohio State Univ., 1967.

Edward John Kennedy, Associate Professor of Aviation Physiology (1972); M.D., Univ. of Iowa College of Medicine, 1962.

David Lee Newton, Commander, U.S. Navy; Instructor in Aeronautical Engineering and Safety (1981); B.S., U.S. Merchant Marine Academy, 1965; M.S., Univ. of West Florida, 1971.

James Edward Novitzki, Lieutenant Commander, U.S. Navy; Assistant Professor of Safety Program Management and Aircraft Accident Prevention (1979); B.A., Univ. of Southern California, 1964; M.A., Laverne Univ., 1974; Ll.B., LaSalle Univ., 1976; Ph.D., United States International Univ., 1977.

**The year of joining the Postgraduate School faculty is indicated in parentheses.*

AVIATION SAFETY OFFICER COURSE

An Aviation Safety Officer (ASO) course is offered eight times per year on a temporary additional duty basis for those commands needing a trained Squadron Safety Officer/Aviation Safety Officer. The course prepares safety officers at the squadron level to assist commanding officers in conducting an aggressive accident prevention program. When the SSO/ASO completes this course he will be able to organize and administer an accident prevention program at the squadron level as defined in OPNAVINST 5100.8.

The six week course consists of approximately 185 classroom hours of safety program management, including mishap prevention techniques, operational aerodynamics and aircraft structures, mishap investigation and reporting, pyschology, law, and aeromedical support. Prior completion of college level courses in algebra and/or physics is highly desirable. Two class field trips will be conducted: A safety survey of an operating squadron or air station; and an industrial activity tour.

Designated naval aviators and naval flight officers of the Navy and Marine Corps of the rank of Lieutenant, USN, and Captain, USMC, and above are eligible to attend. Exceptions must be approved by Type Commanders, or CMC, as appropriate. Details of quota control and class schedules are defined in CNETNOTICE 1520.

RESIDENT COURSES

Officers regularly enrolled in other curricula of the Postgraduate School may qualify for the Aviation Safety Officer Certificate by completing the program requirements: AO 2020, AO 2030, AO 3000, AO 3050, and AO 3060. Substitutions for some of these courses may be made by taking equivalent courses in other departments upon approval of the Director of Aviation Safety. Examples: AO 2020 may be replaced by upper division or graduate courses in aeronautical engineering covering similar topics. AO 3040 may be replaced by upper division or graduate courses in psychology covering similar topics.

AVIATION SAFETY COMMAND COURSE

The Aviation Safety Command (ASC) course is offered seven times a year on a temporary additional duty basis to commanding officers, executive officers, OinC's and officers screened for aviation command. This course consists of approximately 41 hours of such subjects as safety program management, safety psychology, aviation law, aircraft systems, and incidents/accident endorsements. No academic credit is available for this course.

DEPARTMENTAL COURSE OFFERINGS

Upper Division Courses

AO 2020 Aerodynamics for Aircraft Accident Prevention and Investigation (3-0).
Survey of aerodynamics, performance, stability and control of fixed wing/rotary wing aircraft. Effects of varying conditions, configurations, designs and crew techniques on critical areas of operation.

AO 2030 Aircraft Structural Analysis (1-0).
Strength of materials, design criteria, failure mechanisms. Recognition of failures, fatigue, brittle fractures, contribution of manufacturing and maintenance, analysis of evidence, corrosion control technology, and quality control concepts.

Uper Division or Graduate Courses

AO 3000 Problems in Accident Prevention and Investigation (0-4).
Management Theories, practices and techniques, developing applications for the organization and control of a squadron mishap prevention program. Problem-solving exer-

cises in the application of system safety concepts in the squadron accident prevention and investigation effort. Through case-study methods, the course emphasizes mission accomplishment, conservation of resources, cost effectiveness, and systems management in accident prevention, investigation, and reporting.

AO 3040 Safety Psychology (1-0).
Study of human reliability in survival-value environments; personality elements in safety motivation; identification and reduction of problems in human reliability.

AO 3050 Safety Law (1-0).
Study of leading cases and statutes concerning rights and duties in the safety disciplines. Emergency claims; quasicontractural duties. Criminal prosecution of safety violations. Legal duties of care. Special rules of evidence used by the courts in safety-related disputes.

AO 3060 Problems in Aviation Medicine (1-0).
Life-science considerations in accident prevention and investigation. Medical prediction. Effects of hypoxia, dysbarism, G-forces, spatial disorientation, diet, drugs, and exercise upon flight capabilities. Recognition of emotional difficulties; emotional considerations in accident prevention. Interpretation of autopsy reports.

AO 3100 Management Of Accident-Prevention Programs (3-2).
Management theories, practices, communications and controls; automatic data-processing and analysis of accident statistics; legal consideration in safety management; use of systems safety in hazard identification.

AO 3120 Technological Aspects of Accident-Prevention and Analysis (3-2).
Topics include case studies of technological design-related aviation mishaps; identification of structural failure modes; computer and simulator methods in aeronautics; safety-related problems of Navy weapons-system evaluation and acquisition.

Presentation of Excellence in Teaching Award

COMMAND, CONTROL AND COMMUNICATIONS (C3)

C3 Program Exercise Laboratory

The Command, Control and Communications Academic Group has administrative responsibility for the academic content of the Command, Control and Communications program. Teaching in this program is carried out by faculty members attached to the various academic departments associated with the program.

John McReynolds Wozencraft, Professor of Electrical Engineering; Chairman (1977)*; B.S., U.S. Military Academy, 1946; S.M. and E.E., Massachusetts Institute of Technology, 1951; Sc.D., 1957.

Donald Paul Gaver, Jr., Professor of Operations Research and Statistics (1971); S.B., Massachusetts Institute of Technology, 1950; S.M., 1951; Ph.D. Princeton Univ., 1956.

Wayne Philo Hughes, Jr., Captain, U.S. Navy; Chair Professor of Applied Systems Analysis (1979); B.S., U.S. Naval Academy, 1952; M.S., Naval Postgraduate School, 1964.

Jeffrey Wade Johnson, Lieutenant Colonel, U.S. Air Force (1980); B.S., U.S. Air Force Academy, 1964; M.S. in Operations Research, Texas Tech Univ., 1972.

Glenn Frank Lindsay, Associate Professor of Operations Research (1965); B.Sc., Oregon State Univ., 1960; M.Sc., Ohio State Univ., 1962; Ph.D., 1966.

Kneale Thomas Marshall, Professor of Operations Research (1968); B.Sc., (Eng.) Imperial College, London, 1958; M.S., Univ. of California at Berkeley, 1964; Ph.D., 1966.

Kenneth Lee Moore, Captain, U.S. Air Force; Instructor in Electrical Engineering (1980); B.S.E.E., Oklahoma State Univ., 1973; M.S.E.E., Air Force Institute of Technology, 1980.

Paul Henry Moose, Associate Professor of Electrical Engineering (1978); B.S., Univ. of Washington, 1960; M.S., 1966; Ph.D., 1970.

Samuel Howard Parry, Associate Professor of Operations Research (1973); B.S., Georgia Institute of Technology, 1963; M.S., Northwestern Univ., 1964; Ph.D., Ohio State Univ., 1971.

Gary Kent Poock, Professor of Operations Research and Man-Machine Systems (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

George Anthony Rahe, Professor of Computer Science (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

William Reese, Professor of Physics and Defense Technology (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

Francis Russell Richards, Associate Professor of Operations Research (1970); B.S., Louisiana Polytechnic Institute, 1965; M.S., Clemson Univ., 1967; Ph.D., 1971.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY (Command, Control & Communications)

The degree of Master of Science in Systems Technology (Command, Control & Communications) will be awarded at the completion of an interdisciplinary program carried out in accordance with the following degree requirements:

a. The Master of Science in Systems Technology (Command, Control & Communications) requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level.

b. In addition to the 45 hours of course credit, an acceptable thesis must be completed.

c. The program must be approved by the Chairman of the Command, Control and Communications Academic Group.

DEPARTMENTAL COURSE OFFERINGS

CC 0001 Seminar (0-1).
Special lectures and discussion of matters related to the C3 program.

CC 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

Graduate Course

CC 4113 Policies and Problems in C3 (4-0).
An in-depth study of the fundamental role C3 systems fulfill in operational military situations, including crisis warning and crisis management. An analysis of the changing role of intermediate level headquarters and its impact on C3 system requirements and design. Additionally, the course considers the complexities imposed on C3 systems as the force structure becomes more heterogeneous, as in the case of NATO. Case study of selected incidents and systems. Specifically for students in the C3 curriculum. PREREQUISITES: CO 3111, NS 3064.

Graduate Course

CC 4113 Policies and Problems in C3 (4-0).
An in-depth study of the fundamental role C3 systems fulfill in operational military situations, including crisis warning and crisis management. An analysis of the changing role of intermediate level headquarters and its impact on C3 system requirements and design. Additionally, the course considers the complexities imposed on C3 systems as the force structure becomes more heterogeneous, as in the case of NATO. Case study of selected incidents and systems. Specifically for students in the C3 curriculum. PREREQUISITES: CO 3111, NS 3064.

DEPARTMENT OF COMPUTER SCIENCE

EXCELLENCE
AEGIS
STOP
the
THREAT
STUDENT
EXPERIMENTAL
COMPUTER

AEGIS Radar Controller modeling project

Gordon Hoover Bradley, Professor of Computer Science; Chairman (1973)*; B.S., Lehigh Univ., 1962; M.S., 1964; Ph.D., Northwestern Univ., 1967.

Dusan Zdenek Badal, Assistant Professor of Computer Science (1980); Dipl. Ing., Czech Technical Univ., 1965; M.S., Univ. of Saskatchewan, 1971; Ph.D., Univ. of California at Los Angeles, 1979.

Lyle Ashton Cox, Jr., Assistant Professor of Computer Science (1978); A.B., Univ. of California at Berkeley, 1970; L.L.B. LaSalle Univ., 1974; M.S. Univ. of California at Davis, 1976; Ph.D., 1978.

William Marion Faulkner, Adjunct Instructor in Computer Science (1980); B.A., Univ. of California at Berkeley, 1978.

Richard Wesley Hamming, Adjunct Professor of Computer Science (1976); B.S., Univ. of Chicago, 1937; M.S., Univ. of Nebraska, 1939; Ph.D., Univ. of Illinois, 1942.

Uno Robert Kodres, Associate Professor of Computer Science (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

Bruce James MacLennan, Assistant Professor of Computer Science (1979); B.S., Florida State Univ., 1972; M.S., Purdue Univ., 1974; Ph.D., 1975.

Ronald William Modes, Lieutenant Commander, U.S. Navy; Instructor in Computer Science (1981); B.S., Univ. of Utah, 1971; M.S., Naval Postgraduate School, 1977.

Sonja Laura Perdue, Adjunct Research Instructor (1980); B.S., Univ. of California at Irvine, 1972.

George Anthony Rahe, Professor of Computer Science (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

Roger Raymond Schell, Colonel, U.S. Air Force; Associate Professor of Computer Science (1978); B.S.E.E., Montana State College, 1962; M.S.E.E., Washington State Univ., 1963; Ph.D., Massachusetts Institute of Technology, 1971.

Norman Floyd Schneidewind, Professor of Information Science and Computer Science (1971); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966; C.D.P., 1976.

William Robert Shockley, Lieutenant Commander, U.S. Navy; Instructor in Computer Science (1980); B.S., Massachusetts Institute of Technology, 1971; M.S., Naval Postgraduate School, 1980.

Douglas Robert Smith, Assistant Professor of Computer Science (1979); B.S., Boston Univ., 1975, M.S., Duke Univ., 1977; Ph.D., 1979.

Robert Redmond Stilwell, Lieutenant Commander, U.S. Navy; Instructor in Computer Science (1980); B.S., U.S. Naval Academy, 1971; M.S., Naval Postgraduate School, 1978.

**The year of joining the Postgraduate School faculty is indicated in parenthesis.*

MASTER OF SCIENCE IN COMPUTER SCIENCE

1. The degree of Master of Science in Computer Science will be awarded upon the satisfactory completion of a program, approved by the Chairman, Computer Science Department, which satisfies, as a minimum, the following degree requirements:

a. At least 40 quarter hours of graduate level work at which at least 12 quarter hours must be at the 4000 level.

b. The Program shall include at least:

	Quarter Hours
Computer Science	20
Operations Research, Electrical Engineering and/or Management	9
Mathematics, Probability, and Statistics	11

c. Completion of an approved sequence of courses constituting specialization in an area of Computer Science.

d. Completion of an acceptable thesis in addition to the 40 quarter hours of course work.

LABORATORY FACILITIES

The Computer Science Microcomputer Laboratory provides hands-on experience with contemporary microcomputer technology for students in microcomputers, real-time combat computer systems, applications of microelectronics to distributed systems, and innovative architecture designs. The Laboratory provides a test bed facility for student thesis and faculty research in operating systems, multiple processor organizations, and microcomputer software development.

The Laboratory contains a variety of equipment including INTELLEC-8, INTEL MDS-80, ALTOS Z80, AMD Z8000, and DEC LSI-11 systems as well as a number of single board computers. Most of these systems are supported by floppy disk or hard disk storage, CRT data communications terminals and printers. A wide variety of peripheral devices are available for experimentation including bubble memory modules, plasma display devices, robotics testbeds, etc. The Laboratory has communications interfaces to the Computer Center IBM 3033 and to the NPS Computer Laboratory's PDP-11/50 systems. In addition to the wide range of hardware available in the Laboratory, software development is supported in PL/M, PL/Z, PASCAL, PL/1, COBOL, BASIC, and FORTRAN programming languages. Simultaneous multiple-user microcomputer systems are available as are support systems for experimentation with multi-processor configurations designed from single-board computer components.

The Department's classroom instruction, student thesis and faculty research is supported by the facilities of the NPS Computer Laboratories. The Computer Laboratories have developed a multiprocessing system which employs two DEC PDP-11/50's and a PDP-11/34 with a four ported 200 megabyte bulk storage system, 3 tape drives, a CSP Map 300 array processor, a Honeywell 9600 analog tape input system, and thirty time sharing ports. Computer graphics are supported by one or more of each type of graphics terminals (for a total of eleven) including: 3-D vector, conic vector, storage tube, color raster and plasma terminals. Image processing is conducted on an Eyecom 108PT image digitizer and display, a Ramtek 9400, and a Comtal Vision-One system. The Laboratory's system for signal processing provides for analog and digital inputs compatible with tactical and laboratory sources, and includes both fixed point and floating point array processors, interactive graphics, and hardcopy outputs. The graphics capabilities make the Laboratory an acknowledged research and instructional facility.

The facilities of the W.R. Church Computer Center provide timesharing and batch processing for Computer Science classroom instruction and research. The Center has an IBM 3033 Attached Processor with 16 megabytes of memory. The system has an IBM 3850 Mass Store that can hold 38 billion bytes of information. The system supports a wide variety of languages, and applications programs. Timesharing service is provided from 8 terminal/printer locations across the campus.

DEPARTMENTAL COURSE OFFERINGS

CS 0001 Seminar (0-1).
Special lectures; guest lecturers; discussion of student thesis research, faculty research projects.

CS 0110 Fortran Programming (3-0).
The basic elements of FORTRAN are covered with videotape instruction. Practical elements of the principles are afforded by means of a series of problems of increasing difficulty.

CS 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

CS 2010 Introduction to Computers and Data Processing for Non-computer Science Majors (2-0).
An introduction to the general characteristics of contemporary computers and to the functions they serve in a diversity of organizations is provided. The capabilities and limitations of computing as well as the economics of data processing in general are emphasized. There are no prerequisite or corequisite courses. Prior computing experience is not assumed and programming is not taught.

CS 2102 Introduction to Programming in COBOL (1-2).
This course is an introduction to programming using the COBOL language. The course is designed for the student with no previous programming experience who is already familiar with computer fundamentals. PREREQUISITES: CS 2010 or consent of Instructor. *Graded on Pass/Fail basis only.*

CS 2103 Introduction to COBOL Programming (1-2).
This course is designed to provide the student with a basic familiarity in COBOL. The course is intended for the student who is familiar with programming in a higher level language. PREREQUISITE: CS 2810 or consent of Instructor. *Graded on Pass/Fail basis only.*

CS 2106 Introduction to Programming in FORTRAN (1-2).
The course is an introduction to programming using FORTRAN. The course is intended for management students with no previous programming experience who are already familiar with computer fundamentals. PREREQUISITE: CS 2010 or consent of Instructor. *Graded on Pass/Fail basis only.*

CS 2107 Introduction to the CMS-2 Computer Language (1-2).
This course is designed to provide the student with a basic familiarity in CMS-2. The course is intended for the student who is familiar with programming in a higher level language. The course may be taught either as PSI or in self-instructional mode. PREREQUISITE: CS 2810 or consent of Instructor.

CS 2520 Mathematical Modeling and Simulation (4-0).
Continuous simulation based mainly on dynamical systems of ordinary differential equations. Discrete simulations including statistical analysis. PREREQUISITES: MA 2121, and CS 2810.

CS 2600 Introductory Computing and Computer Science for Operations Analysis (2-0).
An introduction to computer problem solving methods for students in the Operations Research curriculum. Topics include subprograms, numerical error control and numerical methods, and program organization and debugging. Emphasis is placed on actual computer programming experience with 5 - 7 operations research related projects of increasing difficulty. Classroom examples and assigned projects are drawn from first quarter Operations Research courses.

CS 2810 Introduction to Computer Science (3-0).
An introduction to computer algorithms, programs and hardware. Algorithms and programs are developed using a structured approach to stepwise refinement of algorithms. The design and testing of computer programs is studied. Computer systems including data representation, computer organization and systems software are studied. PREREQUISITE: One of the following courses must be taken concurrently: CS 2811, CS 2812 or CS 2813.

CS 2811 FORTRAN Programming Laboratory (0-2).
The properly documented solution of scientific and engineering problems using structured FORTRAN is studied. Computer projects of increasing difficulty are assigned. PREREQUISITE: CS 2810 must be taken concurrently or must have been taken in a prior quarter.

CS 2812 Programming Laboratory for Information Sciences (0-2).
The properly documented solution of problems using structured FORTRAN and COBOL is studied. Computer projects of increasing difficulty are assigned. PREREQUISITE: CS 2810 must be taken concurrently or must have been taken in a prior quarter.

CS 2813 PASCAL Programming Laboratory (0-2).
Algorithmic problem solving using PASCAL with emphasis on nonnumeric problems. Properly documented computer projects of increasing difficulty are assigned. PREREQUISITE: CS 2810 must be taken concurrently or must have been taken in a prior quarter.

Upper Division or Graduate Courses

CS 3010 Computing Devices and Systems (4-0).
This course will provide a survey of peripheral computer devices, computer memories, the central processing unit and their interaction and means of communication as they function together. Consideration will be given to the various arrangements of data in the different storage devices and the means of accessing this data. This course examines computer systems from four different levels, the electronic circuit level, the logic or digital device level, the programming level, and the systems level. Each level is covered separately and in relation one to another. PREREQUISITE: IS 2000.

CS 3020 Software Design (3-2).
This course will provide the student with broad background in the concept, design, and development of computer programs. Language selection, program evaluation, testing and debugging, and program documentation will be covered in the lecture portion of the course. The laboratory sessions will be devoted to the development of programming skills and practices as discussed in the lectures, using the American National Standards Institute COBOL language. Projects assigned during the course will be tested, debugged and run on NPS computers. PREREQUISITES: CS 2810 and CS 2812.

CS 3030 Operating Systems Structures (4-0).
This course will provide a broad overview of operating systems including memory management techniques, job scheduling, processor scheduling, device management and data (information) management techniques. Case studies will be included to illustrate the issues in manager-operating system interfaces, operating system selection, data control and security, and operating system utility support. In addition, future trends in computers will be identified, including maxi, mini, and microcomputers. PREREQUISITES: CS 3010 and CS 3020 or equivalent background and consent of Instructor.

CS 3111 Fundamental Concepts of Programming Languages (4-0).
An introduction to the fundamental concepts of programming languages. Analysis of the syntax and semantics of programming languages using formal grammars, the lambda calculus and contour diagrams. Block structure, recursive procedures and methods of parameter passing. Simple interpretive and compiled implementations of programming languages. Basic programming techniques important to language implementation, including recursion and list processing. Comparative study of the name, control and data structuring mechanisms of some common languages. PREREQUISITES: CS 2810 and CS 2813 or consent of Instructor.

CS 3112 Operating Systems (3-2).
This course is an introduction to the fundamental concepts needed to design and understand operating systems and the programming of concurrent processes. Topics discussed include multiprogrammed systems, virtual memory, resource sharing, and process synchronization. Additional design issues involved in timesharing and real-time systems, process scheduling, system communication, and resource management are also briefly reviewed. The laboratory consists of programming projects in a modern, high-level language which illustrate some of these concepts. PREREQUISITES: CS 2810 and CS 3200 or CS 3201 or consent of Instructor.

CS 3113 Introduction to Compilers (3-2).
This course is intended to explore the basics of modern compiler design and construction techniques. The fundamentals of scanning, parsing and compiler semantics are developed in the framework of modern compiler-compiler and translator-writing system technology. The laboratory periods will be used to develop a small model compiler/assembler. Modern languages and current NPS research will be used as examples whenever possible. PREREQUISITES: CS 3111 and CS 3300 or consent of Instructor.

CS 3200 Introduction to Computer Organization (3-2).
This course examines the organization of computers, processor architectures, machine and assembly language programming. Microcomputer systems are used in the laboratory to give students hands-on experience. Included are hardware components: the processor, memories, serial I/O, parallel I/O, real time clock, interrupt control, DMA; processor instructions: information transfer, arithmetic, control, process switching; machine language and assembly language programming: arithmetic functions, input/output, interrupt handling, multicomputer control. PREREQUISITES: CS 2810 and either EE 2810 or EE 2225.

CS 3201 Introduction to Computer Architecture (3-2).
This course examines the organization of computers, processor architecture, machine and assembly language programming. The INTEL 8080A systems are used in the laboratory to give students hands-on experience. Included are hardware components: the processor, memories, serieal I/O, parallel I/O, real time clock, interrupt control, DMA; processor instructions: information transfer, arithmetic, control, machine language and assembly language programming: arithmetic functions, input/output, interrupt handling. PREREQUISITES: CS 2810 and EE 2810 or equivalent.

CS 3202 Computer Graphics (3-2).
An introduction to the hardware and software systems of the principal types of computer graphics terminals. The course will include operation and programming instruction in the higher level languages available in the school's computer laboratory. The student will use graphics command languages to perform exercises on a number of terminals. A major design project in computer graphics is required. Intended for non-computer science students. PREREQUISITE: CS 2810 or equivalent or consent of Instructor.

CS 3204 Coding and Information Theory (4-0).
A quantitive study of the communication process with emphasis on digital communication processes. Coding theory concerns the alternate forms of representation of a set of abstract symbols both for efficiency and error protection. Information theory covers transmission and storage of information. The basic elements, techniques and devices for effective data transmission in computer-based systems, encoding and decoding of data over noisy channels, and communication channels and their capacities are emphasized. A basic knowledge of calculus and probability is assumed. Any additional mathematics, engineering or computer science principles needed to understand the theories are developed within the course.

CS 3300 Data Structures (3-1).
The course deals with the specification, implementation and analysis of data structures. Common data objects such as strings, arrays, records, linear lists, lists and trees, together with the operations used to manipulate these, objects are studied. Particular emphasis is placed on linked structures. Implementation of symbol tables by hash tables and other means is presented. Applications to memory, management, compiler design and sorting/searching algorithms are given. Computer projects in a high level language are required. PREREQUISITES: CS 2810 and CS 2813 or consent of Instructor.

CS 3310 Artificial Intelligence (4-0).
Survey of topics and methods of Artificial Intelligence. Topics include simple learning tasks, visual scene analysis and descriptions, understanding of natural language, computer game playing, knowledge engineering systems. Methods include heuristic search and exploitation of natural constraints, means-ends analysis, production systems, semantic networks, and frames. Emphasis placed on solving problems which seem to require intelligence rather than attempting to stimulate or study natural intelligence. Class and individual projects to illustrate basic concepts. PREREQUISITE: Consent of Instructor.

CS 3400 Comparative Computer Architecture (4-0).
This course will examine computer system design and performance parameters, comparing alternative circuit and subsystem designs, input-output organizations, and the constructions and performance of systems. The effects of hardware design decisions upon user software, data structures and operating system will be considered. PREREQUISITE: CS 3200 or CS 3201 or consent of Instructor.

CS 3502 Computer Communications and Networks (4-0).
This course covers the hardware and software which is used for terminal to computer and computer to computer communication. Emphasis is placed on the study and evaluation of computer networks, such as SNA, DECNET, and ARPANET, and the communications architecture of distributed systems. The material in this course is applicable to real-time military command and control and communications systems, such as those found in WWMCCS, NAVCOMPARS, AUTODIN and supply system networks. PREREQUISITIES: CS 2810; (CS 3010 or its equivalent is strongly recommended).

CS 3550 Computers in Combat Systems (3-2).
This course describes the functions and algorithms of combat systems, the human interaction, and the systems organization in terms of processes. The laboratory experience includes work with navigational, tracking and ballistics functions, display control and the use of wakeup and block primitives in process control. Real-time performance analysis and prediction using simulations is included. PREREQUISITE: CS 3200 or CS 3201 or equivalent.

CS 3601 Automata, Formal Languages and Computability (4-0).
This course will cover the Chomsky hierarchy of Formal Languages (regular sets, context-free languages, context-sensitive languages, and recursively enumerable languages) and the types of grammars and automata associated with each class in the hierarchy. Emphasis is placed on turing machines and decidability questions. Computational intractability and the P=NP question will be covered. PREREQUISITIES: MA 2025 and MA 3026 or equivalent.

CS 3650 Design and Analysis of Algorithms (4-0).
This course focuses on the design and analysis of efficient algorithms. Techniques for analyzing algorithms in order to measure their efficiency are presented. Control structure abstractions, such as divide and conquer, greedy, dynamic programming, back-

track (branch and bound), and local search methods, are studied. The theory of NP-completeness is presented along with current approaches to NP-hard problems. PREREQUISITE: CS 3300.

CS 3800 Directed Study in Computer Sciences (0-2 to 0-8).
Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

CS 3900 Selected Topics in Computer Science (3-0).
Presentation of a wide selection of topics from current literature. Lectures on subjects of current interest and exploration may be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School. Tours of other facilities of interest may also be conducted. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

Graduate Courses

CS 4112 Computer Systems (4-1).
Concepts for hardware and operating system combinations, using techniques for methodical engineering of computer systems with modern architectures; information security is a major emphasis. Specific concepts include addressing; virtual memory; dynamic linking; language support; security kernels, requirements and models; protective domains; file systems; coexisting processes; multiprocessing; virtual and symbolic stream I/O. Considers machine independence, user interface, and architectural implications. PREREQUISITES: CS 3200 and either CS 3112 or CS 3030.

CS 4113 Advanced Language Topics (3-2).
This course covers advanced topics and recent developments in programming languages and compilers. This includes data abstraction mechanisms, extensible languages, synchronization mechanisms, programming environments, applicative languages, functional programming, dataflow languages, message passing semantics, object-oriented programming, very-high-level languages, portability and attribute-grammar. Laboratory period are used for readings from the current programming language literature. PREREQUISITES: CS 3113 and CS 3300 or consent of Instructor.

CS 4202 Interactive Computation Systems (3-2).
A study of the man-computer interface and methods for computer-assisted problem solving. System facilities for man-computer interaction. Computer graphics, transformations, and graphics software. Languages for man-computer interaction. Laboratory work includes a term paper and an individual project using interactive graphical consoles. PREREQUISITE: CS 3111 or consent of Instructor.

CS 4300 Data Base Systems (4-0).
This course presents an up-to-date introduction and exposition of data base systems. The course deals with data base system architectures, physical storage organization, data models, data languages for different data models, design theory for relational data bases, query optimization, data base integrity and security and concurrency control and recovery in data base systems. Also, several commercial data base systems (e.g. IMS) are reviewed. PREREQUISITES: CS 3112 and CS 3300, or consent of Instructor.

CS 4310 Advanced Artificial Intelligence (4-0).
Current Artificial Intelligence systems bring large amounts of task-specific knowledge to bear on a problem in order to gain expert performance. This course focuses on these systems and the techniques used to build them. Of particular importance is the use and representation of knowledge. Applications to natural language understanding, automatic programming, signal understanding, and other topics requiring expertise are studied. PREREQUISITE: CS 3310 or consent of Instructor.

CS 4320 Data Base System Design (4-0).
CS 4320 explores the design of Data Base Systems and current technology of Data Base software. Implementation techniques, viable alternatives, data base philosophies, data manipulation in complex information environments, and system requirements are explored. Examples of systems will be drawn from active DOD data base systems and current application/research in the private as well as public sectors. PREREQUISITE: CS 3020 or knowledge of COBOL or other higher level language and consent of Instructor.

CS 4400 Computer System Performance Evaluation (3-2).
The performance of computer systems — hardware, software, and the users — is the focus of this course. Specific tools used in performance evaluation including analytic modeling, control system modeling, simulation, software monitoring, and hardware monitoring are discussed. The role of performance evaluation in system design and total system life-cycle development is examined in a seminar-like environment. PREREQUISITES: MA 3026, CS 3400, CS 3112 or consent of Instructor.

CS 4500 Software Engineering (3-2).
The techniques for design, development, and management of large scale software systems/projects is the focal theme of this course. Specific topics to be covered include: the nature of software development; software specification and the use of formal specification tools. Software coding; programming methodology, language support, and program maintenance. Software evaluation; performance prediction, validation, testing, and verification. PREREQUISITE: Any 3000-level computer science course.

CS 4550 Distributed Computing (4-0).
The course covers all aspects of computer systems that have multiple computers connected by communications links. Distributed systems architectures, performance and reliability, distributed operating systems and distributed database systems are studied. The course also covers distributed computing related topics in the areas of programming languages, computer science theory and software engineering. PREREQUISITES: CS 3112, CS 3400 and CS 3550.

CS 4800 Directed Study in Advanced Computer Science (0-2 to 0-8).
Directed advanced study in computer science on a subject of mutual interest to student and staff member. Intended primarily to permit students to pursue in depth subjects not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. A written report to the department chairman is required at the end of the quarter. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

CS 4900 Advanced Topics in Computer Science (3-0).
This course examines topics in the fields of current research in computer science. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

CS 4910 Advanced Readings in Computer Science (0-2 to 0-8).
Directed readings in computer science on a subject of mutual interest to student and faculty member. The course allows in-depth study of advanced topics not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. PREREQUISITE: Consent of Instructor.

DEPARTMENT OF ELECTRICAL ENGINEERING

Measuring the signal waveform in the intercommunication network of a multiple microcomputer system

Donald Evan Kirk, Professor of Electrical Engineering; Chairman (1965)*; B.S., Worcester Polytechnic Institute, 1959; M.S., Naval Postgraduate School, 1961; Ph.D., Univ. of Illinois, 1965.

Orestes Methodius Baycura, Associate Professor of Electrical Engineering (1966); B.S.E.E., Carnegie Institute of Technology, 1957; M.S., Univ. of Pittsburgh, 1959; D.Sc. 1963.

John Miller Bouldry, Associate Professor of Electrical Engineering (1946); B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

Stephen Breida, Associate Professor of Electrical Engineering (1958); B.S.E.E., Drexel Institute of Technology, 1952; M.S.E.E., Purdue Univ., 1954.

Daniel Bukofzer, Adjunct Professor of Electrical Engineering (1980); B.S.E.E., California State Univ. at Los Angeles, 1970; M.S.E.E., Univ. of California at Los Angeles, 1972; Ph.D., Univ. of California at Davis, 1979.

Shu-Gar Chan, Associate Professor of Electrical Engineering (1964); B.S., Univ. of Washington, 1954; M.S., Columbia Univ., 1954; Ph.D., Kansas Univ., 1964.

Mitchell Lavette Cotton, Associate Professor of Electrical Engineering (1953); B.S., California Institute of Technology, 1948; M.S., Washington Univ., 1952; E.E., Univ. of California at Berkeley, 1954.

John Henry Duffin, Professor of Electrical Engineering (1962); B.S., Lehigh Univ., 1940; Ph.D., Univ. of California at Berkeley, 1959.

Gerald Dean Ewing, Associate Professor of Electrical Engineering (1963); B.S.E.E., Univ. of California at Berkeley, 1957; M.S.E.E., 1959; E.E. Oregon State Univ., 1962; Ph.D., 1964.

Leon Bernard Garden, Commander, U.S. Navy; Instructor in Electrical Engineering (1981); B.S., Univ. of California at Los Angeles, 1959; M.S., Naval Postgraduate School, 1972.

Alex Gerba, Jr., Associate Professor of Electrical Engineering (1959); B.E.E., Univ. of Louisville, 1947; M.S., Univ. of Illinois, 1957.

Kenneth Gene Gray, Associate Professor of Electrical Engineering (1978); B.S.E.E., Univ. of Houston, 1970; M.S.E.E., 1971; Ph.D., Univ. of Illinois, 1974.

Stephen Jauregui, Jr., Adjunct Professor of Electrical Engineering (1971); B.A., Univ. of California at Berkeley, 1956; M.S., Naval Postgraduate School, 1960; Ph.D., 1962.

Jeffrey Bruce Knorr, Associate Professor of Electrical Engineering (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

Herschel Hare Loomis, Jr., Naval Electronic Systems Command Research Chair Professor (1981); B.E.E., Cornell Univ., 1957; M.S.E.E., Univ. of Maryland, 1959; Ph.D., Massachusetts Institute of Technology, 1962.

Kenneth Lee Moore, Captain, U.S. Air Force; Instructor in Electrical Engineering (1980); B.S.E.E., Oklahoma State Univ., 1973; M.S.E.E., Air Force Institute of Technology, 1980.

Paul Henry Moose, Associate Professor of Electrical Engineering (1980); B.S., Univ. of Washington, (1960); M.S., 1966; Ph.D., 1970.

Michael Allen Morgan, Assistant Professor of Electrical Engineering (1979); B.S.E.E., California State Polytechnic Univ., 1971; M.S., Univ. of California at Berkeley, 1973; Ph.D., 1976.

Glen Allen Myers, Associate Professor of Electrical Engineering (1965); B.S.E.E., Univ. of North Dakota, 1955; M.S.E.E., Stanford Univ., 1956; Ph.D., 1965.

Paul Joel Nahin, Adjunct Professor of Electrical Engineering (1981); B.S., Stanford Univ., 1962; M.S., California Institute of Technology 1963; Ph.D., Univ. of California at Irvine, 1972.

John Everett Ohlson, Professor of Electrical Engineering (1971); B.S. Massachusetts Institute of Technology, 1962; M.S.E.E., Stanford Univ., 1963; Ph.D., 1967.

Rudolf Panholzer, Professor of Electrical Engineering (1964); Dipl. Ing., Technische Hochschule in Graz, Austria, 1953; D.Sc., 1961; M.S.E.E., Stanford Univ., 1956.

Sydney Richard Parker, Professor of Electrical Engineering (1966); B.E.E., City College of New York, 1944; M.S., Stevens Institute of Technology, 1948; Sc.D., 1964.

John Patrick Powers, Associate Professor of Electrical Engineering (1970); B.S.E.E., Tufts Univ., 1965; M.S., Stanford Univ., 1966; Ph.D., Univ. of California at Santa Barbara, 1970.

George Lawrence Sackman, Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D., Stanford Univ., 1964.

Abraham Sheingold, Distinguished Professor of Electrical Engineering (1946); B.S., College of the City of New York, 1936; M.S., 1937.

Donald Alan Stentz, Associate Professor of Electrical Engineering (1949); B.S., Duke Univ., 1949; M.S., Naval Postgraduate School, 1958

Robert Denney Strum, Professor of Electrical Engineering (1958); B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

Tien-Fan Tao, Professor of Electrical Engineering (1971); B.S., National Taiwan Univ., 1955; M.S., Univ. of Pennsylvania, 1958; Ph.D., Harvard Univ., 1963.

George Julius Thaler, Distinguished Professor of Electrical Engineering (1951); B.E., Johns Hopkins Univ., 1940; D. Eng., 1947.

Charles William Therrien, Adjunct Professor of Electrical Engineering (1981); S.B. and S.M., Massachusetts Institute of Technology, 1965; Ph.D., 1969.

Harold Arthur Titus, Professor of Electrical Engineering (1962); B.S., Kansas Univ., 1952; M.S., Stanford Univ., 1957; Ph.D., 1962.

John Robert Ward, Professor of Electrical Engineering (1962); B.Sc., Univ. of Sydney, 1949; B.E., 1952; Ph.D., 1958.

Lonnie Allen Wilson, Associate Professor of Electrical Engineering (1979); B.S.E.E., Walla Walla College, 1965; M.S., Univ. of California at Los Angeles, 1969; Ph.D., 1973.

John McReynolds Wozencraft, Professor of Electrical Engineering (1977); B.S., U.S. Military Academy, 1946; M.S., Massachusetts Institute of Technology, 1951; E.E., 1951; Ph.D., 1957.

Emeritus Faculty

William Malcolm Bauer, Professor Emeritus (1946); B.S., Northwestern Univ., 1927; E.E., 1928; M.S. Harvard Univ., 1929; D.Sc., 1940.

Jesse Gerald Chaney, Professor Emeritus (1944); A.B., Southwestern Univ., 1924; A.M., Univ. of Texas, 1930.

Paul Eugene Cooper, Professor Emeritus (1946); B.S., Univ. of Texas, 1937; M.S., 1939.

Edward Markham Gardner, Professor Emeritus (1948); B.S., Univ. of London, 1923; M.S., California Institute of Technology, 1938.

George Robert Giet, Distinguished Professor Emeritus (1925); A.B., Columbia Univ., 1921; E. E., 1923.

David Boysen Hoisington, Professor Emeritus (1947); B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

Raymond Kenneth Houston, Professor Emeritus (1946); B.S., Worcester Polytechnic Institute, 1938; M.S., 1939.

Clarence Frederick Klamm, Jr., Professor Emeritus (1951); B.S., Washington Univ., 1943; M.S., 1948.

George Heinemann Marmont, Professor Emeritus (1959); B.S., California Institute of Technology, 1934; Ph.D., 1940.

Robert Lee Miller, Professor Emeritus (1946); B.Ed., Illinois State Normal Univ., 1936; M.S., Univ. of Illinois, 1941.

Raymond Patrick Murray, Associate Professor Emeritus (1947); B.S., Kansas State College, 1937; M.S., Brown Univ., 1953.

Herbert LeRoy Myers, Assistant Professor Emeritus (1951); B.S., Univ. of Southern California, 1951.

Charles Benjamin Oler, Professor Emeritus (1946); B.S., Univ. of Pennsylvania, 1927; M.S., 1930; D.Eng., Johns Hopkins Univ., 1950.

Charles Harry Rothauge, Professor Emeritus (1949); B.E., Johns Hopkins Univ., 1940; D.Eng., 1949.

William Conley Smith, Professor Emeritus (1946); B.S., Ohio Univ., 1935; M.S., 1939.

John Benjamin Turner, Jr., Associate Professor Emeritus (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California at Berkeley, 1948.

Allen Edgar Vivell, Dean Emeritus (1945); B.E., Johns Hopkins Univ., 1927; D.Eng., 1937.

Milton Ludell Wilcox, Associate Professor Emeritus (1958); B.S., Michigan State Univ., 1938, M.S., Univ. of Notre Dame, 1956.

** The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN ELECTRICAL ENGINEERING

In addition to meeting the minimum specific academic requirement for these degrees as given below, candidates must also satisfy the general degree requirements as determined by the Academic Council.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

1. A Bachelor of Science in Electrical Engineering or its equivalent is required. Credits earned at the Naval Postgraduate School and credits from the validation of appropriate courses at other institutions are combined to achieve the degree equivalence.

2. To complete the course requirements for the Master's Degree a student needs a minimum of 40 credits in the course sequence 3000 - 4999 of which at least 30 credits must be in Electrical Engineering. Specific courses may be required by the Department and at least four courses, which total a minimum of 12 credits, must be in the course sequence 4000-4999.

3. An acceptable thesis must be presented and approved by the Department.

4. For students who have been admitted to the Engineer's Degree, Doctor of Engineering or Doctor of Philosophy Degree programs and who also desire a Master of Science degree, the thesis requirement may be waived. A Master of Science degree may be awarded to these students after they have completed four 4000 sequence courses, which total a minimum of 12 credits, beyond the course requirements for the Master's Degree.

MASTER OF SCIENCE IN ENGINEERING SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree Master of Science in Engineering Science. The program of each student seeking this degree is to include at least 36 credit hours in the course sequence 3000 - 4999 in the disciplines of engineering, science, and mathematics. At least 12 of these 36 hours must be at the 4000 level, and at least 20 hours are to be in electrical engineering courses. A minimum of 8 quarter hours in 4000-level electrical engineering courses and at least 12 credit hours in courses outside of the Electrical Engineering Department are required. All students must submit an acceptable thesis. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

ELECTRICAL ENGINEER

1. Students with acceptable academic backgrounds may enter a program leading to the degree Electrical Engineer.

2. A minimum of 80 graduate course credits are required for the award of the Engineer's degree. Of these at least 30 hours are to be in courses in the sequence 4000-4999. An acceptable thesis must be completed. A departmental advisor will be appointed for consultation in the development of a program of study. Approval of all programs must be obtained from the Chairman of the Department of Electrical Engineering.

DOCTOR OF PHILOSOPHY AND DOCTOR OF ENGINEERING

The Department of Electrical Engineering has an active program leading to the degrees of Doctor of Philosophy and Doctor of Engineering. Areas of special strength in the department are signal processing, communications systems, electronic systems and control theory. Joint programs with other departments are possible. A noteworthy feature of these programs is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the federal government. The degree requirements are as outlined under the general school requirements for the Doctor's degree.

ELECTRICAL ENGINEERING LABORATORY

The Electrical Engineering Department Laboratories have excellent facilities in almost all phases of modern electrical engineering. These laboratories support classroom instruction and research and are divided into three areas: (1) Devices, Circuits, and Control Systems; (2) Electronic Systems and Signal Processing; and (3) Microwave Devices and Antennas.

The Devices, Circuits, and Control Systems area includes the following laboratory facilities: Control Systems, Analog Computers, Electronic Circuits, Energy Conversion, Digital Systems and Optical Electronics. The Electronic Systems and Signal Processing area includes Radar and Electronic Countermeasures, Satellite Communications, Electro-Optical Image Processing, Sonar, Signal Processing, Communications and Man/Systems Engineering. The Microwave Devices and Antennas area includes Microwave and Antenna laboratory facilities. Status as a naval facility enables the Department to utilize Navy systems in many of the laboratories. The Department also has extensive service facilities which include the Electronic Instrument Repair and Calibration Laboratory, the Printed Circuit Etching Facility, the Equipment "Pool" and the Electronic Component Issue Room. In addition, there are also research spaces available for thesis students to conduct their research problems on an individual basis.

Students also have access to the Computer Center (IBM 3033 System) as well as the Computer Laboratory which is a school-wide computer complex where each student has "hands-on" access to the computer system. These facilities support a wide range of instructional activities and research involving digital and hybrid computation and simulation.

DEPARTMENTAL COURSE OFFERINGS

DEFENSE COMMUNICATIONS COURSES

Upper Division or Graduate Courses

CO 3111 C3 Mission and Organization (4-0).
Organization of the Department of Defense emphasizing command, control, and communications organization. A study of service communication organizations including in-

ter-operability is made. DCS, DSCS, WWMCCS, Nuclear Release Systems, NATO, and Intelligence Reporting Systems organization and network concepts are studied. Command and control facilities, ADP support and executive aids are discussed. PREREQUISITES: U.S. Citizenship and SECRET clearance.

CO 3112 Navy Telecommunications Systems (4-0).
Review of Navy Telecommunications Systems (ship and shore) followed by analysis of technical and managerial problems associated with current and programmed systems. Navy Systems interface with Defense Communications System is discussed. Course entails field trips to telephone, satellite, and message centers. PREREQUISITES: U.S. Citizenship and SECRET clearance.

COURSES FOR ENGINEERING AND SCIENCE CURRICULA

EE 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

EE 0951 Seminar (0-1).
Lectures on subjects of current interest will be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School.

EE 0960 Thesis Topics Seminar (0-1).
Introductory presentations by NPS faculty members of current research projects. Intended to inform first-year students of potential thesis areas.

Upper Division Courses

EE 2101 Circuit Analysis I (3-2).
An introductory course for students with little or no electrical engineering background. The fundamental concepts of voltage, current, power, signals, and sources are developed and applied to the analysis of resistive circuits, including simple transistor amplifiers and the operational amplifier. The principle of superposition, the one-port equivalents due to Thevenin and Norton, and the source transformation theorem are introduced. PREREQUISITE: Linear algebra and calculus (may be concurrent).

EE 2102 Circuit Analysis II (3-2).
A continuation of EE 2101. Following the introduction of the energy-storage elements, dynamic circuits are analyzed with the aid of the Laplace transform. Network functions and other s-domain concepts are developed. Then the special case of the sinusoidal steady-state is examined, using $j\omega$-domain (phasor) methods of analysis. Frequency response, filtering, and ac power are discussed. PREREQUISITE: EE 2101.

EE 2107 Introduction to Electrical Engineering (4-2).
An introductory course intended for students not majoring in electrical engineering. Circuit elements, signals and waveforms; power and energy; Kirchhoff's laws and resistive circuits; diode circuit applications; application of Laplace transform to the step and sinusoidal response of dynamic networks. PREREQUISITE: Calculus (may be concurrent).

EE 2111 Introduction to Avionics Communications (4-2).
The first of a two-course integrated sequence for aeronautical engineering students on avionics systems. A brief introduction to electronic circuit theory and devices, communications principles including basic modulation and detection techniques, digital and spread spectrum, communications systems. PREREQUISITES: Differential equations and Laplace transform.

EE 2130 Review of Circuit Analysis (4-2).
A review of circuit analysis for students with a moderate background in electrical engineering. Starting from a review of the basic concepts of current, voltage, power, signals, and sources, the methods of dynamic circuit analysis are developed through the s- and j -domains. Network functions, frequency response, and ac power are included, as are the more common circuit theorems. PREREQUISITE: Background in electricity through circuit analysis.

EE 2150 Accelerated Review of Circuits and Systems (4-2).
An advanced review of circuits and systems intended for students who have previous education in these areas. The course is conducted primarily in a self-study mode and includes the subject matter of EE 2102 and 2400. PREREQUISITE: Sufficient background in circuits and systems. *Graded on Pass/Fail basis only. (May be taken through Continuing Education as minicourses EE 2151-55.)*

EE 2211 Electronics Engineering I (4-2).
An introduction to electronic devices and circuits. Electrical properties and charge-flow mechanisms of crystalline semiconductor materials; properties of p-n junctions in diodes and bipolar transistors; static models for these devices; characteristics and fabrication of integrated circuits, especially in digital systems; the field effect transistor. PREREQUISITE: A first course in electrical engineering.

EE 2212 Electronics Engineering II (4-3).
Characteristics of discrete device amplifiers and operational amplifiers (OP-AMPS). Analysis and design of amplifiers including frequency response and biasing considerations. Applications of feedback amplifiers and OP-AMPS. PREREQUISITE: EE 2211.

EE 2213 Accelerated Review of Electronics Engineering (4-3).
An advanced review of semiconductor devices and circuits intended for students who have previously studied the subject matter of EE 2211 and EE 2212. PREREQUISITE: Sufficient background in electronic circuits. *Graded on Pass/Fail basis only.*

EE 2215 Applied Electronics (2-4).
A project course covering the application of linear and communications integrated circuits (ICs). Coverage will include an introductory overview of important linear and communications ICs and practical experimental applications of these devices. PREREQUISITES: EE 2212 and EE 2500.

EE 2300 Electromechanical Energy Conversion (3-2).
Concepts of force and torque developed as results of the interaction of magnetic fields are presented as the common basis for all electromechanical machinery. Fundamental characteristics of DC motors and generators, synchronous machines and induction motors are developed and applied. Transformers and control and distribution circuits are also introduced. PREREQUISITE: A course in electric circuits.

EE 2400 Linear Systems Analysis (4-2).
Formulation of system models including state equations, transfer functions, and system diagrams; computer and analytical solution of system equations; frequency analysis using Fourier transform and series; convolution in both the time and frequency domains. PREREQUISITES: Laplace transform, differential equations, FORTRAN, and a course in electric circuits.

EE 2411 Control Systems (4-2).
The application of feedback principles to the design of linear control systems using frequency domain (Bode-Nichols), s-domain (Root Locus) and state variable methods. Performance criteria including steady-state accuracy, transient response specifications, bandwidth and integral performance indices are presented. Laboratory work includes testing and evaluation of physical systems and simulation studies. PREREQUISITE: EE 2400.

EE 2500 Communications Theory (4-2).
In this first course on the transmission of electrical signals, the following concepts are formulated mathematically and then considered in terms of devices and systems: sampling, pulse coding; amplitude, phase, and frequency modulation; time and frequency multiplexing. Basic radio ranging and communications systems are developed and link calculations are made. PREREQUISITES: EE 2400 and EE 2212.

EE 2621 Introduction to Fields and Waves (4-0).
Static field theory is developed and applied to boundary value problems. Time-varying Maxwell equations are developed and solutions to the wave equations are presented. Additional topics include skin effect, reflection of waves and radiation. PREREQUISITE: Vector calculus.

EE 2622 Electromagnetic Engineering (3-1).
A continuation of EE 2621. Topics include transmission lines, waveguides, cavity resonators, and high frequency components. Applications are presented in the laboratory. PREREQUISITE: EE 2621.

EE 2623 Accelerated Review of Electromagnetics (4-1).
A comprehensive review of basic electromagnetic theory intended for students who have previously studied the subject matter of EE 2621 and EE 2622. PREREQUISITE: Sufficient background in electromagnetic theory. *Graded on Pass/Fail basis only.*

EE 2810 Digital Machines (3-3).
An introductory course in the analysis of digital systems and computers. No previous background in electrical engineering or digital techniques is assumed. Topics include: Number systems, logic gates and logic design; arithmetic circuits; flip-flops, counters,

registers, and memories; basic digital computer architecture and the internal operation of computers; and elementary machine-language programming. The laboratories are devoted to the study of logic elements, arithmetic circuits, flip-flops, registers, and counters.

EE 2812 Logic Design (3-2).
A design and project oriented course. Basic principles, theories, and techniques for practical design of digital systems. Emphasizes an integrated viewpoint combining essential elements of classical switching theory with a thorough understanding of the versatility of modern integrated circuits. PREREQUISITES: EE 2810, EE 2211.

Upper Division or Graduate Courses

EE 3111 Avionic Systems (4-2).
The second of a two-course sequence for aeronautical engineering students. Topics include digital communications, radar and EW principles, avionic computers, laser and infrared devices, sonar, navigation systems, and systems and control engineering considerations. PREREQUISITE: EE 2111.

EE 3118 Communications Systems (4-2).
Analog and digital modulation techniques; complete modulation systems incorporating pulse and pulse code schemes; noise in communication systems; error detection and correction. PREREQUISITE: EE 2400.

EE 3210 Advanced Electronics Engineering With Signal Processing Applications (3-2).
Integrated electronics, LSI and acoustic wave devices for processing of analog, digital and sampled analog signals — analog IC's, digital IC's, charge transfer devices. Electronic hardware and firmware implementations of filters and spectral analyzers for signal processing applications — passive filters, active filters, recursive and nonrecursive types of discrete time filters, spectrum analyzers and discrete Fourier transforms. Current advanced electronics developments. PREREQUISITES: EE 2215 and EE 3400 (may be concurrent).

EE 3400 Introduction to Digital Signal Processing (4-0).
Principles of discrete systems, including modeling, analysis and design, with applications to discrete signal processing. Topics include difference equations, z-transforms, stability, frequency response, block diagrams, discrete Fourier transforms and the fast Fourier transform (FTT) algorithm, ideal filters and approximations, design of recursive and non-recursive digital filters. Applications such as the determination of power spectra, filtering of signals and harmonic analysis are considered. PREREQUISITE: EE 2500.

EE 3410 Introduction to Electro-Optical Engineering (3-1).
An overview of the elements that comprise current electro-optical and infrared (EO/IR) systems. Topics include radiation sources (both laser and thermal), detector devices, modulators, optical elements, and propagation characteristics. Examples of various simple EO/IR systems are discussed. PREREQUISITE: EE 2212 (may be concurrent).

EE 3413 Fundamentals of Automatic Control (3-2).
Formulation of system models including state equations, transfer functions, and system diagrams. Starting with a performance measure, design methods are studied for both transfer function and state equation models. Computer simulation is utilized and physical systems are tested and evaluated. PREREQUISITES: Laplace transform and FORTRAN.

EE 3431 Principles of Radar Systems (4-2).
For students in the Avionics and Weapons curricula. Topics include microwave devices, microwave propagation, antenna fundamentals, electronically steerable arrays, pulse radar basics, detection of signals in noise, the radar equation, CW, pulse doppler, moving-target indicators, pulse compression, the ambiguity function, tracking radars, conical scan, track-while-scan, scan with compensation and monopulse. PREREQUISITES: Consent of Instructor, U.S. Citizenship and SECRET clearance.

EE 3472 Principles of Navigation, Missile and Avionics Systems (3-2).
This course covers essentially the same material as EE 3473, but with deletion of detailed analysis of specific systems. This course is intended for officers who do not have U.S. Citizenship. PREREQUISITE: EE 2411.

EE 3473 Navigation, Missile, and Avionics Systems (3-2).
The principles of operation of navigation. missile and avionics systems are presented. Topics are selected from the following areas to address the specific interests of the class: IR, EO, radar, laser, and acoustic sensors; inertial platforms; gyros and accelerometers; Loran, Omega, GPS, guidance, fire control, and tracking systems. PREREQUISITES: EE 2411, U.S. Citizenship and SECRET clearance.

EE 3500 Analysis of Random Signals (4-1).
Fundamental concepts necessary for handling non-deterministic signals and noise in communication, control and signal processing systems are developed. Topics include properties of random time functions, statistical averages, autocorrelation and power spectral density, transform relations, stationarity and ergodicity, noise models. The laboratory exercises illustrate the concepts and principles using real signals. PREREQUISITES: EE 2500 and OS 2102.

EE 3510 Communications Engineering (3-0).
The influence of noise and interference on the design and selection of hardware in practical radio communication transmitters and receivers. Specific topics include link and signal-to-noise ratio calculations, bandwidth trade-offs, carrier and data synchronization methods and hardware parameters. PREREQUISITES: EE 2215 and EE 3500.

EE 3600 Electromagnetic Radiation, Scattering, and Propagation (3-2).
The principles of electromagnetic radiation as applied to antenna engineering and scattering. The characteristics of various practical antenna types are considered. System parameters such as gain, pattern and cross-section are introduced and array theory is covered. Applications including sidelobe suppression, radar target scattering and satellite communications. PREREQUISITE: EE 2622.

EE 3610 Microwave Engineering (3-2).
The elements of microwave systems including circuit media, network characterization with S-parameters and passive circuits such as filters, couplers and impedance transformers. Other topics are solid state devices, linear integrated circuits, electron tubes, microwave and millimeter wave propagation. Laboratory exercises allow the student to pursue selected topics in greater depth in a practical setting. PREREQUISITE: EE 2622.

EE 3800 Microprocessor-Based System Design (3-2).
Develops techniques and design approaches for effective utilization of microprocessors in modern systems. Emphasizes analysis and evaluation of architectural features of microprocessor chip sets. Studies functional organization, capabilities, and utilization of a variety of large-scale monolithic circuits. Software theory and technology is given equal weight with hardware. PREREQUISITE: EE 2812.

EE 3822 System Applications of Computers (3-2).
A system level view of computing resources, including processors, memories, bus structures, interfaces, peripherals and operating systems. Methods applicable to real-time data collection and control are studied. Laboratory projects offer the opportunity for a variety of experience utilizing facilities available in NPS departmental laboratories, in the Computer Center and in the Computer Laboratories. PREREQUISITE: EE 3800.

EE 3850 Data Communication Methods (3-2).
The principles and practice of efficient, reliable data communication. Study of pulse transmission via wire, radio and optical fibers. Modulation, multiplexing and concentration. Synchronous and asynchronous communication. Data link control and line protocols. Architecture of buses and networks. Coding for error control. Interface standards. PREREQUISITE: EE 2500.

Graduate Courses

EE 4121 Advanced Network Theory (4-0).
Topology, circuit formulation, nonlinear modeling, and computer solutions. Circuit sensitivity models. Concepts and test for passivity, activity, causuality, and stability. Driving point synthesis. Transfer function properties and synthesis to meet design criteria. Design with inductorless filters, switched-capacitor filters, operational amplifiers and integrated circuit components. PREREQUISITES: EE 2212 and EE 2400.

EE 4410 Mathematical Models and Simulation for Control Systems (3-2).
Modeling concepts and techniques for linear and nonlinear systems. Philosophy of model studies. Verification of the model and its parameters. Design studies using computer models. PREREQUISITE: EE 2411.

EE 4411 Digital Control Systems (4-0).
Discrete systems are described and analyzed using time-domain and z-transform methods. Analytical design techniques are studied, as well as the engineering characteristics of computer control systems. PREREQUISITES: EE 2411 and EE 3400.

EE 4412 Nonlinear Systems (3-2).
Analysis and design of nonlinear systems with phase plane and describing function methods. Accuracy, limit cycles, jump resonances, relay servos and discontinuous systems are considered. Digital simulation is used extensively. PREREQUISITE: EE 2411.

EE 4413 Linear Optimal Estimation and Control (4-0).
Techniques of optimal control and estimation theory and their application to military systems. Topics include: performance measures; dynamic programming, the linear regulator problem; state estimation using observers and Kalman filters; Monte Carlo simulation; combined estimation and control and case studies. PREREQUISITES: EE 2411 and EE 3500 (may be concurrent).

EE 4415 Design of Linear Control Systems (4-0).
Advanced concepts in the design of linear systems. Frequency response and root locus methods are applied to the design of stabilization and improvement of performance, using both graphical and analytical (algebraic) methods. For more complex systems, the Mitrovic-Siljak relationships are developed, leading to coefficient plane, parameter plane, parameter space, and singular line methods. PREREQUISITE: EE 2411.

EE 4416 Advanced Topics in Modern Control Theory (3-0).
Advanced topics and current developments in control theory and applications including such subjects as: the calculus of variations and Pontryagin's minimum principle applied to optimal control problems; numerical solution of two-point boundary-value problems; nonlinear estimation techniques; large-scale systems; system identification; case studies of fire control and ship control systems. PREREQUISITES: Consent of Instructor or EE 4413.

EE 4418 Ship Control Systems (3-2).
Theory of motion of ships. Basic ship control systems: steering control, roll stabilization, boiler control loops, speed and propulsion controls. Sea states and their effects. Performance objectives and performance specifications; models and simulation studies. PREREQUISITE: EE 2411.

EE 4422 Electro-Optic Systems Engineering (3-1).
Advanced topics and applications of electro-optics. Military applications of infrared technology. Signal-to-noise analysis of laser detector performance. Descriptions of high energy lasers, fiber optics or other topics. Student reports on EO/IR topics of current interest. PREREQUISITE: EE 3410.

EE 4432 Radar Systems (3-2).
The principles of pulse radar systems are developed in classroom and laboratory exercises. Additional topics developed include the radar equation, doppler systems, MTI automatic-target-tracking systems, pulse compression, and multiple-unit steerable-array radars. PREREQUISITES: EE 3500 and EE 3610 (may be concurrent), or equivalent. *This course is intended for students who do not have U.S. Citizenship.*

EE 4433 Radar Systems (3-2).
The radar range equation is developed in a form including signal integration, the effects of target cross-section, fluctuations, and propagation losses. Modern techniques discussed include pulse compression frequency-modulated radar, MTI, pulse doppler systems, monopulse tracking systems, multiple-unit steerable array radars, and synthetic aperture systems. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with pulse compression, and with the measurements of radar cross section of targets. PREREQUISITES: EE 3500 and EE 3610 (may be concurrent), or equivalent; U.S. Citizenship and SECRET clearance.

EE 4451 Sonar Systems Engineering (4-1).
Theory and engineering practices pertain-to passive and active sonar systems. Current fleet systems and developmental projects are analyzed. The objective of the course is to determine how the engineering design is conditioned by characteristics of the transmission medium as well as operational requirements. PREREQUISITES: PH 3452, EE 4572, or EE 4716, U.S. Citizenship and SECRET clearance.

EE 4452 Underwater Acoustic Systems Engineering (4-1).
A study of the theory and engineering principles of underwater acoustics, communications, surveillance, and echo ranging systems. Emphasis is placed on the principles and problems common to all underwater acoustic systems, and the design tradeoffs that are available to the engineer. The laboratory periods are used for making engineering tests on existing systems and testing a subsystem of the student's own design. PREREQUISITE: EE 3500.

EE 4460 Principles of Systems Engineering (4-0).
An introduction to the concepts, principles, methodology, and techniques of the design of large scale systems. Lecture topics include the systems approach; the system life cycle and system design process; determining system requirements from operational requirements; system effectiveness, reliability, maintainability, safety, and logistic support considerations; test and evaluation; and cost as a design parameter. Applications to Navy electronics systems are used to illustrate the subjects covered. A detailed case study analysis of a specific Navy system is performed by the students. PREREQUISITE: Consent of Instructor.

EE 4461 Systems Engineering (4-0).
An introduction to the engineering of large scale systems. The primary aim of this course is to increase the student's awareness of the complex interactions of various disciplines and the main recurring problems in systems engineering. The class participates in a group project involving a feasibility study of a proposed new system. PREREQUISITE: Consent of Instructor.

EE 4481 Electronic Warfare Techniques and Systems (3-3).
All aspects of electronic warfare are covered: receivers for electronic support measures and electronic intelligence, signal identification, active and passive electronic countermeasures techniques for radar and for communications, electronic countercountermeasures methods and circuits, defense against missile systems, and test and evaluation methods for electronic warfare. Electro-optic systems are briefly covered. PREREQUISITES: EE 4433, U.S. Citizenship, and SECRET clearance.

EE 4482 Signals Intelligence (SIGINT) Systems Engineering (2-2).
Airborne, shipboard, and ground based interept and direction finding system techniques used against simple and sophisticated electromagnetic radiation systems. Among the topics covered are current state of the art for wideband and directional antennas, wideband RF preamplifiers, scanning and chirping receivers, displays, recorders, pattern recognizers, and signal analysis devices. The laboratory periods are largely devoted to the specification and block diagram of systems to handle specified SIGINT tasks. PREREQUISITES: EE 4481 or permission of Instructor; U.S. Citizenship and SECRET clearance.

EE 4483 Principles of Electronic Warfare *(unclassified)* (3-2).
For students who do not have U.S. Citizenship. The objectives are to define the EW signal and system parameters, and to establish the interrelationships of these parameters for both active and passive electronic warfare systems. Among the topics studied are: intercept receivers, signal waveforms and spectra, signal processing and display, jamming signals and systems, direction finding, passive techniques, and the use of the computer and other new devices in modern EW systems. PREREQUISITE: EE 4432.

EE 4485 Electronic Warfare (4-1).
This course is intended for students who are not in the Electronics or Communications Engineering curricula. Three lecture hours are shared with EE 4481. In addition to the topics listed under EE 4481, background material on communication theory and digital signal processing is presented. PREREQUISITES: EE 3431, U.S. Citizenship and SECRET clearance.

EE 4550 Digital Communications (4-0).
Digital communications is becoming increasingly important in military systems. This course discusses some of the advantages and limitations of digital communications systems, to include: packet switching, cryptographic protection, pulse code modulation, frame and bit synchronization, telephone line modems, intersymbol interference and adaptive equalizers, wide-band modems, exchange of band-width and signal-to-noise ratio, diversity combining, and error detection and correction techniques. PREREQUISITE: EE 3510.

EE 4560 Communications ECCM (3-2).
Methods of reducing the effects of jamming on radio communications systems are considered. Matched filter and correlator theory and application to spread spectrum techniques of digital data transmission are treated. Synchronization problems and techniques are presented. Codes for error correction are briefly considered. Frequency hopping, time hopping, and hybrid systems are studied in addition to direct sequence spreading. Use of steerable null antennas is described. PREREQUISITE: EE 3510.

EE 4565 High Frequency Techniques (4-0).
The high frequency path from transmitter multicoupler to receiver multicouplers. Topics include HF propagation, propagation prediction, sounders, the ionosphere, noise and interference, dynamic range problems, site effects, and target location techniques. PREREQUISITES: EE 3600, or consent of Instructor; U.S. Citizenship and SECRET clearance.

EE 4572 Statistical Communication Theory (3-2).
Advanced statistical methods applied to the analysis of signals and noise in communications systems, including applications to radar and sonar. Topics may include the reponse of linear and nonlinear systems, error measures, optimal filters, decision schemes, parameter estimation, and applications to analog and digital communications. The laboratory provides the student with the opportunity to do independent analytical studies, experimental work, or computer simulation related to the properties of signals and noise. PREREQUISITE: EE 3500.

EE 4581 Information Theory (4-0).
Concepts of information measure for discrete and continuous signals. Fundamental theorems relating to coding and channel capacity. Effects of noise on information transmission. Coding methods for error control in digital communication systems. Selected applications of the theory to systems. PREREQUISITE: EE 3500.

EE 4591 Communication Satellite Systems Engineering (3-0).
Communication satellite systems including the satellite and user terminals. Subjects include orbits, power sources, antennas, stabillization, link calculations, multiple access techniques, modulation and demodulation schemes, phase-locked loops, coding, transponder intermodulation and hardlimiting, receiver design, spread spectrum in SATCOM for multiple access, anti-jam and covert communications. PREREQUISITE: EE 3510.

EE 4623 Advanced Electromagnetic Theory (3-0).
Advanced topics in electromagnetic theory as selected by the instructor. PREREQUISITE: EE 3600, or consent of Instructor.

EE 4823 Advanced Digital Architectures and Applications (3-1).
Recent developments in digital systems. Topics may include: machine organization, computer graphics, man-machine interfaces, design automation, parallel processing, pipeline processing, array computers, multiprocessors, new microprocessors and microcomputers, memory management for microprocessors, and integrated circuits for microcomputer peripherals. An individually planned experimental project or library research project involving state-of-the-art utilization of computer hardware and software is required. PREREQUISITE: EE 3800.

EE 4845 Principles of Digital Filters (4-0).
Design and implementation of digital signal processing algorithms. Included are a review of FIR and IIR linear filter design techniques with emphasis on structures, implementations, and quantization effects (finite register lengths, correlated and uncorrelated noise). Least square estimation filters including discrete Wiener filtering (stochastic deconvolution), linear prediction, autoregressive moving average processing, Levinson's algorithm and lattice structures, and self-adaptive filters. Multidimensional filtering with 2-D transforms and recursive algorithms. PREREQUISITE: EE 3400.

EE 4875 Advanced Digital Methods (3-2).
Evolving trends in state-of-the-art digital systems. Examples of present and projected VLSI technology. Current concepts of computer architecture and relation of architecture to applications. Models, design techniques and descriptive languages for system specification. Microprogramming as a hardware implementation tool. Memory hierarchies. Virtual, cache, interleaved and associative memory. Parallel and pipeline processing. Multiple CPU systems. Peripheral interfacing. Digital communication and bus structures. Laboratory work involves experiments and projects with mini and microcomputer systems. PREREQUISITE: EE 3800.

EE 4900 Special Topics in Electrical Engineering (2-0 to 5-0).
Supervised study in selected areas of electrical engineering to meet the needs of the individual student. A written report is required at the end of the quarter. PREREQUISITE: Consent of the Department Chairman. *Graded on Pass/Fail basis only.*

EE 4910 Advanced Topics in Electrical Engineering (3-0 or 4-0).
This course examines advanced topics of current interest in the field of electrical engineering. PREREQUISITE: Consent of Instructor.

COURSES FOR INTERDISCIPLINARY CURRICULA

EE 0110 Electrical Principles Refresher (5-2).
A six-week course designed to introduce and/or refresh incoming officers in selected basic concepts of electrical engineering. The laboratory periods are used to learn to operate modern electronic test equipment.

Upper Division Courses

EE 2003 Communications Systems (4-0).
This course supports the Naval Intelligence curriculum by providing an overview of the principles, concepts, and trade-offs underlying communications systems. Topics include: signals and their representation as functions of time and frequency, effects of bandwidth limitations upon signals, analog and digital modems, signal-to-noise considerations in communications systems, reliable communications path concepts, major communications system design trade-offs, and examples of modern communications systems.

EE 2418 Control Systems (2-1).
This course develops the basic tools of the control systems engineer. The applications to electronic warfare are emphasized in the examples and laboratory experiments. The dynamics for a radar control system, a missile seeker head tracking system and missiles are investigated. Basic topics are introduced such as signal flow graphs and system step and frequency response characteristics, and digital systems theory as used in radar tracking and command guided and semiactive homing missiles. PREREQUISITES: Differential equations, Laplace transform and FORTRAN.

EE 2422 Communications Systems (3-2).
Digital and analog communications systems with identification of subsystems; sampling, code conversion oscillators, modulation and demodulation, special purpose circuits, elementary communication theory, Fourier analysis, ideal filters, and multiplexing techniques. PREREQUISITE: EE 2721.

EE 2424 Signal Transmission Systems (4-1).
The elements of electrical energy transmission as applied to communications. The principles of electromagnetic waves, guided waves on transmission lines, and waveguides are studied. The radiated field in space, antennas, and propagation are covered, and a representative system, such as a satellite communications system is studied. PREREQUISITE: EE 2422.

EE 2624 Electromagnetic Theory (4-1).
The experimental laws of electromagnetic theory and the development of Maxwell's equations are presented. Maxwell's equations are then utilized in the study of plane waves, transmission lines, wave guides, cavity resonators, and elementary radiation. Laboratory experiments dealing with high frequency components and measurements reinforce and extend the concepts presented in the lectures. PREREQUISITES: MA 2181 and EE 2721.

EE 2721 Introduction to Electronic Systems (4-1).
A first course in electronic systems for the ASW, EW, and Telecommunications Systems curricula. Emphasis is on the functional aspects of basic circuits and signals. Topics include electrical quantities, resistive circuits, inductance and capacitance, operational amplifiers, time and frequency response, rectifiers and logic elements. PREREQUISITE: Calculus.

EE 2722 Introduction to Signals & Systems (4-1).
Overview of communication and sensor systems, to include: voice circuits, data circuits, communication networks, radar and sonar, electro-optics, and SIGINT. Identification of common technological themes. Representation of linear systems by transfer functions, synthesis and analysis of signals in terms of sinusoids, Fourier analysis, system input/output relations in the time and frequency domain. Application to scaling and approximation of signals, frequency and time division multiplexing, and target identification. PREREQUISITE: Calculus.

Upper Division or Graduate Courses

EE 3425 Communication System Analysis (3-2).
The final course in the Telecommunications Systems sequence. The objective is to study the overall communication system with concentration in the system aspects rather than in devices. Topics include: signal waveforms and spectra, modulation techniques, power budget, diversity systems, propagation problems, codes and error control, network components, protocol, and system planning considerations including possible trade-offs. PREREQUISITE: EE 2424.

EE 3625 Electromagnetic Radiation, Scattering, and Propagation (4-2).
The fundamentals of antennas used in the VLF through the microwave portion of the electromagnetic spectrum. Scattering and propagation in this part of the spectrum are also discussed, as are those elements of electromagnetic compatibility which relate to radiation. Laboratory exercises relating to pattern and impedance measurement, and use of computer programs further enhance the student's understanding of the lecture concepts. PREREQUISITE: EE 2624.

EE 3714 Introduction to Signals and Noise (4-1).
A course in the analysis of signals and noise for the ASW and EW curricula. Topics include Fourier analysis of periodic and pulse signals, linear filter response, correlation and spectral density of random signals and sampling. PREREQUISITES: EE 2721 and a first course in probability.

EE 3715 Signals & Noise (4-1).
Detailed block diagrams of selected communication and sensor systems. Comparison and contrast of analog & digital systems. Power spectrum characterization of noise temperature. Baseband equivalent signals. Signal-to-noise ratio and matched-filter reception. Probability of error for binary & M-ary signaling. Spread spectrum signaling for jam-resistance and low probability of intercept. PREREQUISITE: EE 2722.

Graduate Courses

EE 4423 Electro-Optic Systems and Countermeasures (3-1).
A study of military applications of electro-optic systems, IR and EO missile seekers, laser designators, optical surveillance, high energy laser systems, laser communications, and laser radar. Emphasis is on system applications, countermeasures and counter countermeasures. PREREQUISITES: PH 3271 or EE 4422; U.S. Citizenship and SECRET clearance.

EE 4434 Microwave Devices and Radar (4-2).
Those microwave devices most important in radar and in electronic warfare systems are studied, including magnetrons, traveling-wave tubes, and solid-state diodes. The radar range equation is developed. In addition to basic pulse radar, modern techniques are discussed including doppler systems, tracking radar, pulse compression, and electronically steerable array radars. Electromagnetic compatibility problems involving radar systems are considered. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with performance measurement methods, automatic tracking systems, pulse compression, and the measurement of radar cross section of targets. PREREQUISITES: EE 4716, EE 3625 (may be taken concurrently) or consent of Instructor, U.S. Citizenship and SECRET clearance.

EE 4484 Electronic Warfare Systems (3-2).
This course covers electronic warfare in that portion of the electromagnetic spectrum through the millimeter wavelength region. The infrared through electro-optic region is covered in a companion course, EE 4423. Electronic denial and deceptive countermeasures against fuses, communications, and various radar detection and tracking systems are discussed. Equations for required jammer gain and power output are developed. The characteristics of passive countermeasures are discussed. Other topics include anti-radiation missiles, counter countermeasure circuits, target masking and modification, signal intercept, signal sorting, signal identification, and direction finding. Techniques are discussed in relation to U.S., allied, and communist bloc systems. Laboratory work reinforces the classroom discussions. PREREQUISITES: EE 4434, U.S. Citizenship and SECRET clearance.

EE 4489 Electronic Warfare and C3 Systems (4-0).
The vulnerability of command, control, and communication systems to electronic warfare and signal analysis is examined. A background in electromagnetic propagation in layered media is developed and used to investigate phenomena such as ionospheric propagation, ducting, and electromagnetic attenuation in seawater. The dependence of propagation phenomena on frequency is illustrated with examples taken from ELF through millimeter waves. Elementary antennas are treated, with emphasis on their farfield patterns. The directional properties of array antennas are developed and used to study electronically-steered multiple-beam antennas such as those used in Aegis. The capabilities and limitations of direction-finding intercept antennas are discussed. SIGINT system operations are explored from the points of view of both offense and defense. Specifically for students in the C3 curriculum. PREREQUISITE: EE 3715.

EE 4540 Telecommunications Networks (4-0).
Transmission of digital data, to include modulation/demodulation and error detection/correction techniques. Multiple access via line switching, packet switching, and ALOHA techniques. Analysis of queuing, blocking, delay and thruput. Protocol requirements, routing, and flow control in large-scale interconnected systems. Subnetwork compartmentalization, digitized voice and network reliability. Examples of existing and proposed systems. PREREQUISITE: EE 4489.

EE 4716 Signal Processing Systems (4-1).
A study of digital, analog, and hybrid signal processing systems for communications, echo ranging, and electronic surveillance. Examples from current and proposed military systems will be analyzed. The course is designed for the ASW and EW curricula. PREREQUISITE: EE 3714.

Experimental research in Radar Target Identification

ELECTRONIC WARFARE

Electronic Warfare experiment

The Electronic Warfare Academic Group has administrative responsibility for the academic content of the Electronic Warfare Systems Technology curriculum. Teaching in this multi-disciplinary program is carried out by faculty members attached to the following academic departments: Computer Science, Electrical Engineering, Mathematics, Meteorology, National Security Affairs, Operations Research, and Physics and Chemistry. Members of the Academic Group are:

John Miller Bouldry, Associate Professor of Electrical Engineering; Chairman (1946)*; B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

Alfred William Madison Cooper, Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's Univ. of Belfast, 1961.

Jeffrey Bruce Knorr, Associate Professor of Electrical Engineering (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

Robert Alexander Persell, Jr., Commander, U.S. Navy; B.A., Univ. of Virginia, 1961; M.S. in International Affairs, George Washington Univ., 1971; M.S. in Management, Naval Postgraduate School, 1975.

William Reese, Professor of Physics and Defense Technology (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

Gordon Everett Schacher, Professor of Physics (1964); A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

Arthur Loring Schoenstadt, Associate Professor of Mathematics (1970); B.S., Rensselaer Polytechnic Institute, 1964; M.A., 1965; Ph.D., 1968.

Alan Robert Washburn, Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

Lonnie Allen Wilson, Associate Professor of Electrical Engineering (1979); B.S.E.E., Walla Walla College; M.S., Univ. of California at Los Angeles, 1969; Ph.D., 1973.

**The year of joining the Postgraduate School Facility is indicated in parentheses.*

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

1. The degree of Master of Science in Systems Technology will be awarded at the completion of a multidisciplinary program, Curriculum 595, satisfying the following degree requirements:
    a. The Master of Science in Systems Technology requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four different academic disciplines must be included, and in two disciplines, a course at the 4000 level must be included.
    b. An approved sequence of at least three courses constituting advanced specialization in one area must be included.
    c. In addition to the 45 hours of course credit, an acceptable thesis must be completed.

DEPARTMENTAL COURSE OFFERINGS

EW 0002 Seminar (0-1).
Special lectures and discussion of matters related to the EW program. PREREQUISITE: SECRET clearance.

EW 0810 Thesis Research/Group Project (0-0).
Students in the Systems Technology curricula will enroll in this course which consists of an individual thesis or a group project involving several students and faculty.

Upper Division or Graduate Courses

EW 3020 Electronic Warfare Computer Applications (3-2).
Application of digital and analog techniques to the recording, processing, display, and interpretation of electronic warfare signals and data. The computer is applied to the solution of electronic warfare problems such as signal identification. PREREQUISITES: EE 2810, CS 3510, or CS 3230; EE 4484.

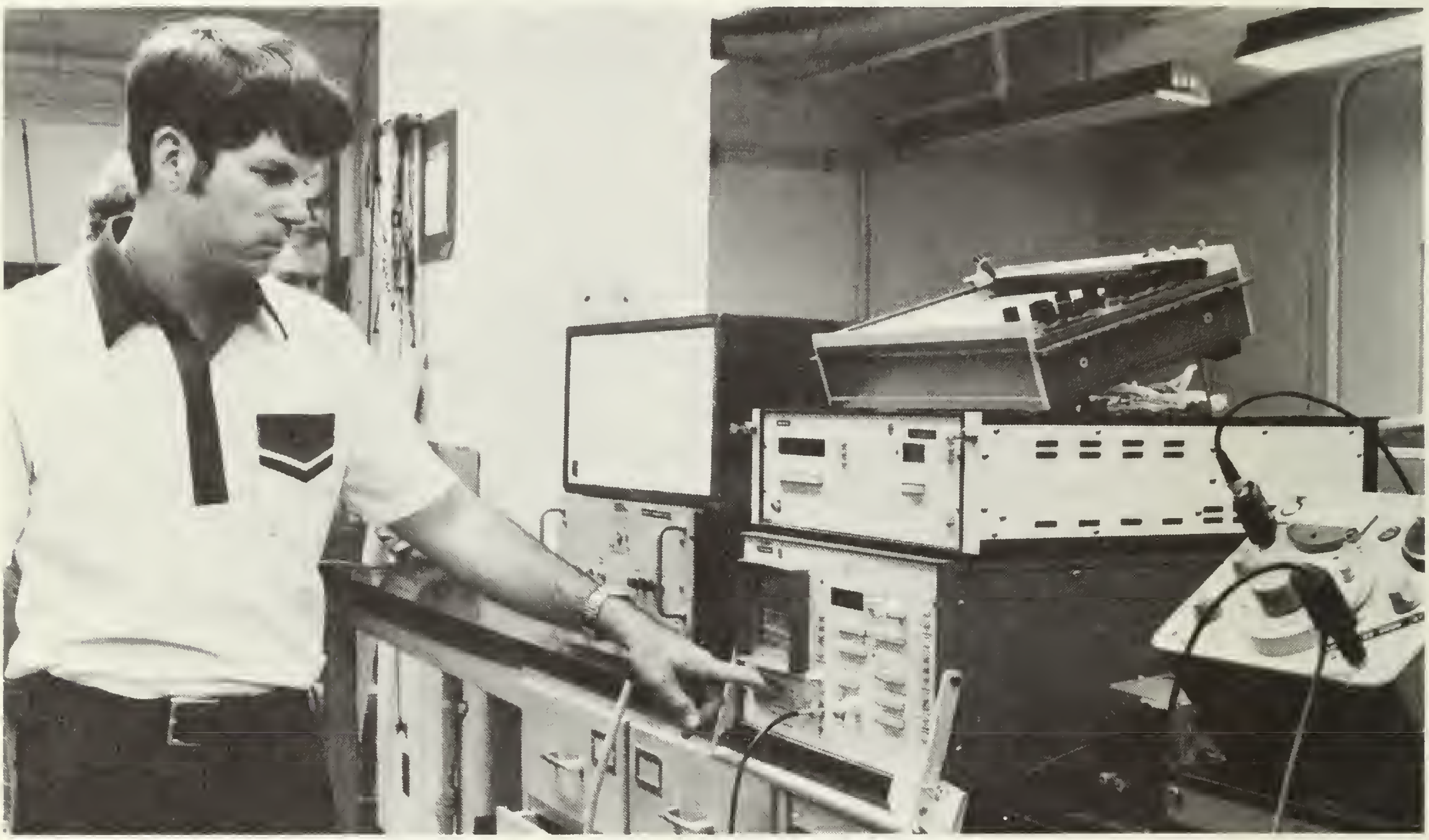
EW 3486 Signals Intelligence (2-0).
This course focuses on U.S. signals intelligence capabilities for countering current threats and the processes for designing or upgrading U.S. capabilities. It is designed to enhance the student's knowledge and understanding of current and planned U.S. SIGINT systems and capabilities and the design, development and employment of SIGINT and ESM systems. PREREQUISITE: Registration in EW curriculum 595 or consent of Instructor. U.S. Citizenship and SI clearance.

Graduate Course

EW 4453 Underwater Sound, Systems, and Countermeasures (3-2).

A study of the principles of underwater sound propagation, and the design and operational characteristics of underwater sound systems. Emphasis is placed on various measures used to interfere with and to deceive active and passive Sonar systems, and the techniques used to counter this interference. Topics studied include: sensor arrays, acoustic propagation, noise, acoustic quieting, signal processing, and examples of active and passive underwater acoustic systems, including acoustic countermeasures. PREREQUISITES: PH 2123, U.S. Citizenship and SECRET clearance.

ENGINEERING ACOUSTICS



Student examining spectrum of an acoustic signal

The academic character of programs in Engineering Acoustics is interdisciplinary, with courses drawn principally from the fields of electrical engineering and physics. Although broadly based, the emphasis is on those aspects of acoustics concerning propagation of sound in the oceans, on applications of underwater sound and on the electrical engineering of instrumentation for detection of underwater sounds. These programs are designed for students in the Underwater Acoustics Curriculum.

The academic aspects of the programs are the responsibility of an academic committee, chaired by P.H. Moose, Associate Professor of Electrical Engineering, with C.L. Burmaster, G.L. Sackman, O.B. Wilson, and O. Heinz (Academic Associate), as members.

DEGREE REQUIREMENTS MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

1. A student pursuing a program leading to a Master of Science in Engineering Acoustics must have completed work which would qualify him for a Bachelor of Science degree in engineering or physical science. Credit requirement for the Master of Science degree must be met by courses in addition to those used to satisfy this requirement.

2. The Master of Science in Engineering Acoustics requires a minimum of 36 graduate credit quarter hours of course work; at least 20 graduate quarter hours must be taken in acoustics and its applications. One 4000 level course from each of three of the following areas must be included: wave propagation, vibration and noise control, transducer theory, sonar systems, and signal processing.

3. An acceptable thesis must be completed.

4. Approval of each program by the Engineering Acoustics Academic Committee.

DOCTOR OF PHILOSOPHY DOCTOR OF ENGINEERING

The Departments of Electrical Engineering and Physics & Chemistry have a new interdisciplinary program leading to either the degree Doctor of Philosophy or Doctor of Engineering. Areas of special strength in the departments are physical acoustics, ocean acoustics, and acoustic signal processing. A noteworthy feature of these programs is that a portion of the student's research may be conducted away from the Naval Postgraduate School at a cooperating laboratory or other federal government installation. The degree requirements and examinations are as outlined under the general school requirements for the Doctor's degree. In addition to the school requirements, the departments require a preliminary examination to show evidence of acceptability as a doctoral student.

Honors recipient, June 1981 Graduation

DEPARTMENT OF MATHEMATICS

Demonstrating a Pascal Program on a microcomputer

Carroll Orville Wilde, Professor of Mathematics; Chairman (1968)*; B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

Garrett Birkhoff, Adjunct Professor of Mathematics (1981); A.B., Harvard Univ., 1932; Postgraduate, Cambridge, England, 1933; Honorary Doctor, National Univ. of Mexico, 1951.

Richard Homer Franke, Associate Professor of Mathematics (1970); B.S., Fort Hays Kansas State College, 1959; B.S., Univ. of Utah, 1961; Ph.D., 1970.

Harold Marvin Fredricksen, Associate Professor of Mathematics (1980); B.A., Los Angeles State College, 1962; M.S., Univ. of Wisconsin, 1964; Ph.D., Univ. of Southern California, 1968.

Philip Hartman, Adjunct Professor of Mathematics (1980); B.A., The Johns Hopkins Univ., 1934; Ph.D., 1938.

Michael Donald Humphries, Adjunct Professor of Mathematics (1980); A.B., Wm. Jewell College, 1975; M.S., 1977; Ph.D., Univ. of Missouri, 1980.

Toke Jayachandran, Associate Professor of Mathematics (1967); B.S., V.R. College, Nellore, India, 1951; M.S., Univ. of Wyoming, 1962; Ph.D., Case Institute of Technology, 1967.

Ladis Daniel Kovach, Professor of Mathematics (1967); B.S., Case Institute of Technology, 1936; M.S., 1948; M.A., Western Reserve Univ., 1940; Ph.D., Purdue Univ., 1951.

Gordon Eric Latta, ONR Research Professor of Mathematics (1979); B.S., Univ. of British Columbia, 1946; Ph.D., California Institute of Technology, 1951.

Kenneth Robert Lucas, Associate Professor of Mathematics (1958); B.S., Washburn Univ., 1949; Ph.D., Univ. of Kansas, 1957.

Herman Bernhard Marks, Associate Professor of Mathematics (1961); B.S., Southern Methodist Univ., 1950; M.A., Univ. of Texas, 1959.

George William Morris, Professor of Mathematics (1968); B.A., Southwestern Oklahoma State Univ., 1942; M.A., Univ. of Oklahoma, 1947; Ph.D., Univ. of California at Los Angeles, 1957.

Guillermo Owen, Adjunct Professor of Mathematics (1979); B.S., Fordham Univ., Ph.D., Princeton Univ., 1962.

Ira Bert Russak, Associate Professor of Mathematics (1972); M.E., Stevens Institute of Technology, 1957; M.A., Univ. of California at Los Angeles, 1962; Ph.D., 1967.

Arthur Loring Schoenstadt, Associate Professor of Mathematics (1970); B.S., Rensselaer Polytechnic Institute, 1964; M.A., 1965; Ph.D., 1968.

Donald Herbert Trahan, Associate Professor of Mathematics (1966); B.S., Univ. of Vermont, 1952; M.A., Univ. of Nebraska, 1954; Ph.D., Univ. of Pittsburgh, 1961.

Peter Cheng-Chao Wang, Associate Professor of Mathematics and of National Security Affairs (1970); B.A., Pacific Lutheran Univ., 1961; M.A., Wayne State Univ., 1962; Ph.D., 1966.

Maurice Dean Weir, Associate Professor of Mathematics (1969); B.A., Whitman College, 1961; M.S., Carnegie-Mellon Univ., 1963; D.A., 1970.

Emeritus Faculty

Willard Evan Bleick, Professor Emeritus (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

Frank David Faulkner, Distinguished Professor Emeritus (1950); B.S., Emporia State Univ., 1940; M.S., Kansas State Univ., 1942; Ph.D., Univ. of Michigan, 1969.

Robert Eugene Gaskell, Professor Emeritus (1966); A.B., Albion College, 1933; M.S., Univ. of Michigan, 1934; Ph.D., 1940.

Joseph Giarratana, Professor Emeritus (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

Carl Adolf Hering, Professor Emeritus (1946); B.S., Oregon State College, 1941; M.S., Cornell Univ., 1944.

Brooks Javins Lockhart, Professor Emeritus (1948); B.A., Marshall Univ., 1937; M.S., West Virginia Univ., 1940; Ph.D., Univ. of Illinois, 1943.

John Philip Pierce, Professor Emeritus (1948); B.S.E.E., Worcester Polytechnic Institute, 1931; M.S.E.E., Polytechnic Institute of Brooklyn, 1937.

Robert Fross Rinehart, Dean Emeritus (1965); B.A., Wittenberg College, 1930; M.A., Ohio State Univ., 1932; Ph.D., 1934; D.Sc., Wittenberg Univ., 1960.

Elmo Joseph Stewart, Professor Emeritus (1955); B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Univ., 1953.

James Woodrow Wilson, Professor Emeritus (1949); B.A., Stephen F. Austin State, 1935; B.S., in Ch.E., Univ. of Texas, 1939; M.S., in Ch.E., Texas A&M College, 1941.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MATHEMATICS

The Department of Mathematics offers the Master of Science degree to qualified students. An interested student should consult the Chairman of the Mathematics Department for an evaluation of his previous academic record to determine his potential for successfully completing a degree program.

If the student's previous record is found to be adequate, a mathematics program is designed which satisfies the Departmental requirements and fits the interest, preparation and aptitude of the student. The program, and subsequent changes in the program, must be approved by the Departmental Chairman.

A student whose background is deemed insufficient for entrance may take courses to reach entrance level, however such courses cannot be counted toward degree requirements.

MASTER OF SCIENCE IN APPLIED MATHEMATICS

1. In order to enter a program leading to the degree Master of Science in Applied Mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics or, with a strong mathematical orientation, in a physical science or engineering.

2. A program that leads to the degree Master of Science in Applied Mathematics for a student who has met the entrance criterial must contain a minimum of 45 quarter hours of graduate level courses with a minimum QPR of 3.0, subject to the following conditions:

   a. The program must be approved by the Chairman of the Department of Mathematics.

   b. The program must include at least fifteen hours at the 4000 level, with at least twelve hours in 4000 level mathematics courses.

   c. The program must contain at least nine hours in an approved sequence of applications courses from outside the Mathematics Department, and at least nine hours in an approved sequence of courses from within the Mathematics Department.

   d. An acceptable thesis is normally required and is credited as the equivalent of nine hours of 3000 level mathematics courses. (A student may petition the Chairman of the Mathematics Department to substitute nine hours of courses for the thesis.)

   e. Courses in the following areas are specifically required in any program; some of these courses may be used to satisfy part (or all) of the mathematics sequence requirement in item (2.c.) above:
      (1) Real/complex analysis (a two-course sequence), or applied algebra (a two-course sequence)
      (2) Ordinary and/or Partial Differential Equations and Integral Transforms
      (3) Numerical Analysis
      (4) Probability and Statistics

MASTER OF SCIENCE DEGREE WITH MAJOR IN MATHEMATICS

1. In order to pursue a program leading to the Master of Science degree with a major in mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics.

2. A curriculum which satisfies the Master of Science degree requirements consists of a minimum of 45 quarter hours of approved courses in mathematics and related subjects. An acceptable thesis may be counted as equivalent to nine quarter hours. A student must have a QPR of 3.0 or greater in any major program.

3. At the discretion of the Chairman of the Department of Mathematics, a student pursuing a program leading

to the Master of Science degree with major in mathematics may (or may not) be required to write a thesis in mathematics.

4. The following topics are specifically included in any major program.
   a. 6 hours of Algebra
   b. 6 hours of Analysis

5. The main areas of thesis topics are
   a. Optimization
   b. Differential Equations
   c. Fourier Analysis
   d. Functional Analysis
   e. Numerical Methods
   f. Optimal Control
   g. Calculus of Variations
   h. Tensor Analysis and Applications

DEPARTMENTAL COURSE OFFERINGS

MA 0112 Refresher Mathematics (5-5).
Calculus Review.

MA 0125 Logic and Set Theory (5-0).
An introduction to the elements of set theory and mathematical reasoning. Sets, Venn Diagrams, truth tables, quantifiers, logical reasoning. Functions, relations, partitions and equivalence relations. 1-1 correspondence. (Paradoxes of set theory, axiom of choice.) PREREQUISITE: None.

MA 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

Lower Division Courses

MA 1021 Precalculus Mathematics (4-0).
Brief review of algebraic fundamentals. Algebra of complex numbers, quadratic equations. Systems of equations. Trigonometric functions of the general angle. Identities. Solution of right triangles. Elements of the theory of equations. Introduction to analytic geometry.

MA 1110 Introduction to the TI-59 Programmable Calculator (2-0).
Numerical calculations and basic programing on the TI-59 programmable calculator. Numerical calculations include use of the power and root keys, log and exponential keys, trigonometric and inverse trigonometric keys, and scientific and floating point notation. Basic programming includes use of the label and editing keys, read and write keys, printing, conditional and unconditional branching, loops, subroutines, use of the solid state library modules, and indirect addressing. (A TI-59 programmable calculator is required; a PC-100A printer is desirable, but not required.) *Graded on Pass/Fail basis only.*

MA 1112 Selected Calculus Topics Review (2-2).
Functions, limits, continuity, differentiation of functions of one and several variables, implicit functions, parametric equations, optimization; indefinite, definite and multiple integrals; sequences and series, series representation of functions; Euler's formula; review of complex numbers. PREREQUISITE: A previous course in calculus.

MA 1114 Single Variable Calculus and Infinite Series (5-0).
Review of basic functions such as polynomials, trigonometric functions and exponentials. Calculus of a single variable to include limits, derivatives and integrals, and approximate methods. Roots of functions and solutions of systems of linear equations. Complex algebra. Infinite sequences and series with applications. PREREQUISITE: MA 0114 or equivalent. This course is designed for students in the C3 curriculum.

MA 1115 Single Variable Calculus (5-0).
Review of analytic geometry and trigonometry, functions of one variable, limits, derivatives, continuity and differentiability; differentiation of algebraic, trigonometric, logarithmic and exponential functions with applications to maxima and minima, rates, differentials; product rule, quotient rule, chain rule; antiderivatives, integrals and the fundamental theorem of calculus; definite integrals, areas, lengths of curves and physical applications; special methods of integration. PREREQUISITE: Precalculus mathematics *(May be taken through Continuing Education as mini-courses MA 1131-36).*

MA 1116 Multivariable Calculus (5-0).
Review of calculus of one variable; vector algebra and calculus, directional derivative, gradient and integral theorems; maxima and minima of functions of two independent variables, total differential; double and triple integrals, cylindrical and spherical coordinate systems; infinite series, convergence tests, uniform convergence and Taylor series. PREREQUISITE: Previous course in calculus. *(May be taken through Continuing Education as mini-courses MA 1137-40 and 1150.)*

MA 1117 Calculus Laboratory I (0-2).
A problem solving course associated with MA 1115.

MA 1118 Calculus Laboratory II (0-2).
A problem solving course associated with MA 1116.

Upper Division Courses

MA 2025 Logic, Sets and Functions (4-1).
Propositional logic, elements of set theory, relations, functions and partitions. An introduction to theorem proving techniques, including mathematical induction, in the context of basic mathematical systems.

MA 2035 Mathematical Introduction to Microprocessors (1-2).
An introduction to microprocessors at the hardware/software interface. Machine language programming, assembly language programming, connecting and controlling peripherals (terminal, disc drive...), operating systems. PREREQUISITES: Ownership or access to an 8080/Z80 or 6502 based microprocessor; no technical requirements.

MA 2042 Linear Algebra (4-0).
Systems of linear equations, matrices, and determinants. Finite dimensional vector spaces, linear dependence, basis, dimension, inner products, orthogonalization. Linear transformations, rank and nullity, change of basis, linear functionals, orthogonal transformations, quadratic forms, symmetric matrices, diagonalization, eigenvalues and eigenvectors. PREREQUISITES: MA 1115.

MA 2047 Linear Algebra and Vector Analysis (4-0).
Solutions of linear systems of equations, algebra of matrices, determinants. Linear vector spaces, linear dependence and independence, subspaces, bases and dimension. Inner products, ortho-normal bases and Gram-Schmidt process. Eigenvectors and eigenvalues. The algebra and calculus of vectors in R^2 and R^3. Del operator, directional derivative, gradient, divergence and curl with applications. Line, surface and volume integrals, Green's Stoke's and divergence theorems. PREREQUISITE: MA 1116 (may be taken concurrently).

MA 2110 Multivariable Calculus (4-0).
Integrated with linear algebra. Functions of several variables, continuous transformations, jacobians, chain rule, implicit function theorem, inverse function theorem, extrema, Lagrange multiplier technique, curvilinear coordinates. PREREQUISITE: MA 1116 or equivalent, MA 2042 or equivalent concurrently.

MA 2121 Differential Equations (4-0).
Ordinary differential equations: linear and non-linear equations, homogeneous and nonhomogeneous equations, linear independence of solutions, power series solutions, systems of differential equations, Laplace transfors applications. PREREQUISITE: MA 1116 or equivalent, MA 2047 or equivalent concurrently.

MA 2125 Differential Equations (3-0).
An abbreviated version of MA 2121, without Laplace transforms. PREREQUISITE: MA 1116 or equivalent, MA 2047 or equivalent concurrently.

MA 2129 Ordinary Differential Equations and Laplace Transforms (2-1).
First order ordinary differential equations second order equations with constant coefficients, application, Laplace transforms. PREREQUISITE: Differential and integral calculus.

MA 2151 Introduction to Complex Variables and Numerical Methods (4-0).
Analytic functions, Laplace's equation, rational functions; line integrals in the plane, Cauchy's integral theorem, indefinite integration, Cauchy's integral formula. Taylor series, finite differences, roots of equations, linear equations, numerical integration. PREREQUISITES: FORTRAN programming and MA 1116.

MA 2181 Vector Calculus (2-1).
Differentiation and integration of vector functions. The del operator and related concepts. Green's theorem, Stokes' theorem, divergence theorem. Interpretations and applications. PREREQUISITE: Calculus and vector algebra.

MA 2300 Mathematics for Management (5-0).
This course is designed to provide a mathematical basis for modern managerial tools and techniques. It includes elements of differential and integral calculus, sequences and series and an introduction to matrix algebra. PREREQUISITE: College algebra.

MA 2310-2311 Mathematics for Naval Intelligence I-II (5-3) and (5-2).
A review of linear, logarithmic, sinusoidal and exponential functions, with graphical emphasis; differentiation and integration, with both analytical and numerical procedures, continuation to include introductory treatments of Fourier analysis; the Fourier integral, spectral analysis, differential equations and the Laplace transformation. Descriptive statistics and data presentation, discrete probability and the binomial and Poisson distributions, continuous probability, the normal distribution and the central limit theorem, hypothesis testing, estimation and correlation, small samples. Students' t-distribution, the Chi-square distribution. Single and multiple regression, computation, data processing and analysis. PREREQUISITE: College algebra and trigonometry.

MA 2400 Introduction to Vectors, Matrices and Vector Calculus (3-0).
The algebra of vectors and matrices. Systems of linear equations, determinants; eigenvalues. Directional derivative, gradient, divergence, curl; line, surface and volume integrals; integral theorems; applications. PREREQUISITE: Differential and integral calculus.

MA 2401 Introduction to Differential Equations and Complex Functions (4-1).
Ordinary differential equations including series solutions and Laplace transforms; Fourier series and partial differential equations; complex analytic functions. PREREQUISITE: Differential and integral calculus.

Upper Division or Graduate Courses

MA 3026 Discrete Mathematics and Automata Theory (5-0).
Analysis of algorithms. Elementary concepts of semigroups, monoids, and groups. Regular languages and finite state automata. Context-free languages and pushdown automata. Applications to computer science. PREREQUISITE: MA 2025.

MA 3046-3047 Linear Algebra I-II (3-0).
Special types of matrices; orthogonal reduction of a real symmetric matrix to diagonal form; quadratic forms and reductions to expressions involving only squares of the variables; applications to maxima and minima; Lambda matrices and related topics; Cayley-Hamilton theorem. Reduced characteristic function; canonical forms, idempotent and nilpotent matrices; solutions to matrix polynomial equations; functions of a square matrix; applications such as to differential equations, stability criteria. PREREQUISITE: MA 2042.

MA 3132 Partial Differential Equations and Integral Transforms (4-0).
Solution of boundary value problems by separation of variables; Sturm-Liouville problems; Fourier, Bessel and Legendre series solutions, Laplace and Fourier transforms; classification of second order equations; applications. PREREQUISITE: MA 2121 or equivalent.

MA 3139 Fourier Analysis and Partial Differential Equations (4-0).
Solution of the one-, two-, and three-dimensional wave equations by separation of variables and characteristics; d'Alembert's solution; ray propagation; Fourier analysis applied to ordinary and partial differential equations; convolution theorems. *For ASW students.* PREREQUISITE: MA 2129.

MA 3181 Vector Analysis (3-0).
Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems; applications in various fields of engineering. PREREQUISITE: MA 1116 or equivalent.

MA 3185 Tensor Analysis (3-0).
Definition of tensor. Algebra of tensors. The metric tensor. The geometric representation of vectors in general coordinates. The covariant derivative and its application to geodesics. The Riemann tensor, parallelism, and curvature of space. PREREQUISITE: Consent of Instructor.

MA 3232 Numerical Analysis (3-2).
Solution of nonlinear equations, zeros of polynomials. Interpolation and approximation. Numerical differentiation and quadrature. Matrix manipulations; linear simultaneous algebraic equations, eigenvalues. Numerical solutions of ordinary differential equations. Analysis for computational errors. PREREQUISITE: MA 2121 or equivalent (may be taken concurrently) and FORTRAN programming.

MA 3243 Numerical Methods for Partial Differential Equations (4-1).
Finite difference approximations for derivatives. Truncation and discretization errors. Parabolic and hyuperbolic equations. Explicit and implicit methods. The Crank-Nicolson method. Approximations at irregular boundaries. Elliptic equations, the Liebmann method. Systems of partial differential equations. Students are expected to write FORTRAN programs for the above methods. PREREQUISITE: MA 3132 and FORTRAN programming.

MA 3362 Orbital Mechanics (3-0).
Review of kinematics, Lagrange's equation of motion. The earth's gravitational field. Central force motion. The two body problem. Perturbations. PREREQUISITE: Consent of Instructor.

MA 3560 Modern Applied Algebra (3-0).
An introductory course in the techniques and tools of abstract algebra with special emphasis on applications to coding theory, radar and communications systems and computer science. Elements of set theory, equivalence relations and partitions. Semigroups, groups, subgroups and homomorphisms. Rings, ideals and fields. Directed graphs and lattices. Applications may vary. PREREQUISITE: Consent of Instructor.

MA 3565 Modern Algebra I (3-0).
An advanced course in the subject of abstract algebra. Semigroups, groups, subgroups, normal subgroups. Groups acting on sets, operator groups. The Jordan-Holder Theorem, solvable groups. The Krull Schmidt Theorem. PREREQUISITE: MA 3560 or consent of Instructor.

MA 3605-3606 Fundamentals of Analysis I-II (3-0).
Elements of set theory, the real number system, and the usual topology of En; properties of continuous functions; differential of vector-valued functions, Jacobians, and applications (implicit function, inverse function theorem, extremum problems). Functions of bounded variation and theory of Reimann-Stieltjes integration, multiple and iterated integrals, convergence theorems for sequences and series of functions. PREREQUISITE: Consent of Instructor.

MA 3610 Introduction to General Topology (3-0).
Topologies, bases and subbases, compactness and connectivity. Moore-Smith convergence theorems. Metrization and embedding theorems, uniform structures. Tychonoff product theorem, Alexandroff and Stone Cech compactification. PREREQUISITE: MA 3605.

MA 3675-3676 Theory of Functions of a Complex Variable I-II (3-0).
Selected topics from the theory of functions of a real variable; complex functions, power series, Laurent series. Singularities of complex functions; residues and contour integration; zeros of analytic functions, factors of and infinite product representation for analytic functions; maximum modulus theorems for analytic and harmonic functions; conformal mapping. PREREQUISITE: Consent of Instructor.

MA 3730 Theory of Numerical Computation (3-0).
Analysis of computational methods used for the solution of problems from the areas of algebraic equations, polynomial approximation, numerical differentiation and integration, and numerical solution of ordinary differential equations. PREREQUISITE: Consent of Instructor.

Graduate Courses

MA 4237 Advanced Topics in Numerical Analysis (Variable credit, usually (4-0)).
The subject matter will vary according to the abilities and interest of those enrolled. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

MA 4393 Topics in Applied Mathematics (3-0).
A selection of topics in applied mathematics. The course content varies. Credit may be granted for taking this course more than once. PREREQUISITE: Consent of Instructor.

MA 4501 Topics in Foundations of Mathematics (3-0).
A selection of topics in foundations of mathematics. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. *Graded on Pass Fail basis only.*

MA 4566 Modern Algebra II (3-0).
A continuation of MA 3365. Rings, ring homomorphism, integral domains and euclidean domains. Unique factorization rings, polynominal rings. Modules and ideals. Noetherian rings, Field extension and Galois theory. PREREQUISITE: MA 3565.

MA 4593 Topics in Algebra (3-0).
A selection of topics in algebra. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

MA 4611 Calculus of Variations (3-0).
Euler equation, Weierstrass maximum principle, Legendre condition, numerical procedures for determining solutions, gradient methods, Newton's method, transversality condition, Rayleigh-Ritz method, conjugate points, and applications. PREREQUISITE: MA 2121 (programming experience desirable).

MA 4620 Theory of Ordinary Differential Equations (3-0).
Introduction to the modern theory of ordinary differential equations. Systems of equations. Theoretical and constructive methods of solutions. PREREQUISITE: Consent of Instructor.

MA 4622-4623 Principles and Techniques of Applied Mathematics I-II (3-0).
Linear operators, generalized functions and Hilbert spaces; solutions of partial differential equations by eigenfunctions; variational techniques and their applications to eigen functions; integral equations, Laplace, Fourier and other transforms, including their inversion in the complex plane as applied to partial differential equations; method of characteristics for hyperbolic equation. PREREQUISITE: MA 3132 or equivalent.

MA 4630 Functional Analysis in Numerical Analysis (3-0).
Metric spaces, Banach spaces, Hilbert space, uniform boundedness principle, Banach fixed point theorem. Applications to error estimates, convergence and stability; numerical linear algebra, numerical integration, and numerical solution of differential and integral equations. PREREQUISITES: MA 2121, MA 2042, MA 3232, MA 3605-06.

MA 4635-4636 Functions of Real Variables I-II (3-0).
Semi-continuous functions, absolutely continuous functions, functions of bounded variation; classical Lebesque measure and integration theory, convergence theorems and Lp spaces. Abstract measure and integration theory, signed measures, Radon-Nikodym theorem; Lebesque decomposition and product measure; Daniell integrals and integral representation of linear functionals. PREREQUISITE: MA 3606.

MA 4672 Integral Transforms (3-0).
The Laplace, Fourier and Hankel transforms and their inversions. Applications to problems in engineering and physics. PREREQUISITE: MA 2172.

MA 4693 Topics in Analysis (3-0).
A selection of topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor.

MA 4872 Topics in Calculus of Variations (3-0).
Recent development of the numerical solution of problems in the calculus of variations. Foundations of numerical methods, applications to control problems. Differentials, perturbations, variational equations, adjoint system, conditions for optimum. Euler equations, maximum principle of Weierstrass and Pontryagin, the Legendre condition. Methods of solution: special variations, variation of extremals, dynamic programming. Applications in ship routing and missile control. PREREQUISITES: MA 2121 and computer programming or Consent of Instructor.

DEPARTMENT OF MECHANICAL ENGINEERING

Students receive instruction on a diesel engine experiment

Paul James Marto, Professor of Mechanical Engineering; Chairman (1965)*; B.S., Univ. of Notre Dame, 1960; M.S., in Nuc. Engr., Massachusetts Institute of Technology, 1962; Sc.D., 1965.

Peter George Bellamy-Knights, Adjunct Professor of Mechanical Engineering (1981); B.Sc., Leicester Univ., 1963; M.Sc., 1967; Ph.D., Manchester Univ., 1970.

Gilles Cantin, Professor of Mechanical Engineering (1960); B.A. Sc., Ecole Polytechnique at Montreal, 1950; M. Sc., Stanford Univ., 1960; Ph.D., Univ. of California at Berkeley, 1968.

Kenneth David Challenger, Assistant Professor of Materials Science (1979); B.S.M.E., Univ. of Cincinnati, 1967; M.S.MET.E., 1971; Ph.D., 1973.

Grant Richard Garritson, Captain, U.S. Navy; Assistant Professor of Mechanical Engineering (1979); B.S., U.S. Naval Academy, 1961; Ph.D., Univ. of Notre Dame, 1968.

Benjamin Gebhart, Naval Sea Systems Command Research Chair Professor (1980); B.S., Univ. of Michigan, 1948; M.S., 1950; Ph.D., Cornell Univ., 1954.

Matthew Dennis Kelleher, Associate Professor of Mechanical Engineering (1967); B.S., Univ. of Notre Dame, 1961; M.S.M.E., 1963, Ph.D., 1966.

Terry Robert McNelley, Associate Professor of Materials Science (1976); B.S.M.E., Purdue Univ., 1967; Ph.D., Stanford Univ., 1973.

Robert Eugene Newton, Professor of Mechanical Engineering (1951); B.S.M.E., Washington Univ., 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951.

Robert Harry Nunn, Professor of Mechanical Engineering (1968); B.S., Univ. of California at Los Angeles, 1955; M.S.M.E., 1964; Ph.D., Univ. of California at Davis, 1967.

Arthur Jeffery Perkins, Associate Professor of Materials Science (1972); B.S., Drexel Institute of Technology, 1965; M.S., Case Institute of Technology 1967; Ph.D., in Metallurgy, Case Western Reserve Univ., 1969.

Paul Francis Pucci, Professor of Mechanical Engineering (1956); B.S., Purdue Univ., 1949; M.S.M.E., 1950; Ph.D., Stanford Univ., 1955.

John Winston Rose, Adjunct Professor of Mechanical Engineering (1981); B.Sc., Univ. of London, 1958; Ph.D., 1964; D.Sc., 1979.

David Salinas, Associate Professor of Mechanical Engineering (1970); B.S., Univ. of California at Los Angeles, 1959; M.S., 1962; Ph.D., 1968.

Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering (1967); B.S.M.E., Tech. Univ. of Istanbul, 1950; M.S.M.E., 1951; Ph.D., Univ. of Iowa, 1954.

Joseph Francis Sladky, Jr., Adjunct Professor of Mechanical Engineering (1980); B.S.C.E., West Virginia Univ., 1968; M.S.M.E., 1969.

Garret Neil Vanderplaats, Associate Professor of Mechanical Engineering (1979); B.S.C.E., Arizona State Univ., 1967; M.S.C.E., 1968; Ph.D., Case Western Reserve Univ., 1971.

Emeritus Faculty

Roy Walters Prowell, Professor Emeritus (1946); B.S. in I.E., Lehigh Univ., 1936; M.S.M.E., Univ. of Pittsburgh, 1943.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MECHANICAL ENGINEERING

A specific curriculum must be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Chairman of the Department of Mechanical Engineering at least two quarters before completion. In general, approved programs will require more than minimum degree requirements in order to conform to the needs and objectives of the United States Navy.

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

Undergraduate Preparation. A candidate shall have completed work equivalent to the Bachelor of Science requirements of this department. Candidates who have minor deficiencies, or who would like to review their undergraduate material, may utilize the NPS Continuing Education Program which offers a variety of courses in the self-study mode.

Approved Curriculum. The candidate must take all courses in a curriculum approved by the Chairman of the Department of Mechanical Engineering. At minimum, the approved curriculum must satisfy the requirements below.

Required Courses. The Master of Science degree in Mechanical Engineering requires at least 32 quarter hours of graduate level credits in Mechanical Engineering and Materials and Science, at least 10 of which must be at the 4000 level. In addition, at least 8 quarter hours of graduate credit must be earned outside of Mechanical Engineering and Materials Science.

Thesis. An acceptable thesis is required for the Master of Science in Mechanical Engineering degree. An acceptable thesis for the Mechanical Engineering degree may also be accepted as meeting the thesis requirement for the Master's degree. Approval of the thesis topic must be obtained from the Chairman of the Mechanical Engineering Department. An advisor will be appointed by the Chairman of the Mechanical Engineering Department for consultation in the development of a program of research.

MASTER OF SCIENCE IN ENGINEERING SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree Master of Science in Engineering Science (with major in Mechanical Engineering).

The program must include at least 36 credit hours of graduate work in the disciplines of engineering, science and mathematics, 12 of which must be at the 4000 level. Of these 36 hours, at least 20 hours (8 of which must be at the 4000 level) must be in Mechanical Engineering and Materials Science.

In addition, the program must contain at least 12 hours at the graduate level in courses outside Mechanical Engineering and Materials Science.

The student seeking the degree Master of Science in Engineering Science must submit an acceptable thesis. Programs leading to this degree must be approved by the Chairman of the Mechanical Engineering Department.

THE PROGRAM LEADING TO THE DEGREE: MECHANICAL ENGINEER

A graduate student with a superior academic record may enter a program leading to the degree Mechanical Engineer. A candidate is normally selected after completion of his first year of residence.

The candidate must take all courses in a curriculum approved by the Chairman of the Department of Mechanical Engineering. At minimum, the approved curriculum must satisfy the requirements stated in the paragraphs below.

The Mechanical Engineer degree requires at least 60 quarter hours of graduate level credits in Mechanical Engineering and Materials Science, and in addition, at least 12 quarter hours of graduate level credits must be earned outside of Mechanical Engineering and Materials Science. At least 30 of the above required graduate level credits must be at the 4000 level.

An acceptable thesis is required for the Mechanical Engineer degree. Approval of the thesis program must be obtained from the Chairman of the Mechanical Engineering Department. An advisor will be appointed by the Chairman of the Mechanical Engineering Department for consultation in the development of a program of research.

DOCTOR OF PHILOSOPHY AND DOCTOR OF ENGINEERING

The Department of Mechanical Engineering has an active program leading to the degrees of Doctor of Philosophy and Doctor of Engineering. Areas of special strength in the department are hydrodynamics, viscous flows, heat transfer, materials science, structural mechanics, and finite element analysis.

Joint programs with other departments are possible. A noteworthy feature of the program leading to the Doctor of Engineering degree is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the Federal Government. The degree requirements are as outlined in the general school requirements for the Doctor's degree.

MECHANICAL ENGINEERING LABORATORIES

The Mechanical Engineering Laboratories are designed as complements to the educational mission and research interests of the department. In addition to the extensive facilities for the support of student and faculty research, a variety of general use equipment is available. This includes machinery for the investigation of dynamic and static problems in engineering mechanics; a completely equipped materials science laboratory, including a scanning electron microscope; a water tunnel, and a wave channel; facilities for experimentation with air flows from incompressible through supersonic velocities; equipment for instruction in thermal transport phenomena; a laboratory for demonstrating nuclear engineering principles; and an interactive computer graphics laboratory. Experimentation is further enhanced by a broad selection of analog and digital data acquisition and processing equipment and instrumentation.

DEPARTMENTAL COURSE OFFERINGS

MECHANICAL ENGINEERING

ME/MS 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

ME 0951 Seminars (0-1).
Lectures on subjects of current interest are presented by NPS faculty and invited experts from other universities and government and industrial activities.

Lower Division Course

ME 1000 Preparation for Professional Engineers Registration (3-0).
The course will cover the topics from the 8-hour Professional Examination given by the State of California for Professional Engineer. Discussion will involve applicable engineering techniques, including design and analysis of mechanical systems and components. *Graded on Pass/Fail basis only.*

Upper Division Courses

ME 2101 Engineering Thermodynamics (4-1).
A comprehensive coverage of the fundamental concepts of classical thermodynamics, with insight toward microscopic phenomena. The laws of thermodynamics. Equations of state. Thermodynamic properties of substances. Entropy, irreversibility and availability. Cycle analysis. Gas-vapor mixtures. Combustion and dissociation. PREREQUISITE: MA 1116. *(May be taken through Continuing Education as mini-courses ME 2111-15.)*

ME 2201 Introduction to Fluid Mechanics (3-2).
Properties of fluids. Hydrostatics and stability of floating and submerged bodies. Fluid flow concepts and basic equations in steady flows: mass, momentum, and energy considerations. Dimensional analysis and dynamic similitude. Viscous effects and fluid resistance. Drag and separated flow over simple bluff bodies. Emphasis on naval engineering applications and problem solving. PREREQUISITE: ME 2502.

ME 2410 Mechanical Engineering Lab I (2-3).
Fundamentals of mechanical measurement systems, structured laboratory experiments using resistance strain gages, pressure transducers, temperature, flow and velocity measurement devices. PREREQUISITES: ME 2101, ME 2201, and ME 2601, any of which may be taken concurrently. *Graded on Pass/Fail basis only.*

ME 2501 Statics (3-0).
Forces and moments, particles and rigid bodies in equilibrium. Simple structures, friction, first moments and centroids. PREREQUISITE: MA 1116 (may be concurrent). *(May be taken through Continuing Education as mini-courses ME 2511-13.)*

ME 2502 Dynamics (3-2).
Kinematics. Newton's laws and d'Alembert's principle. Work and energy. Impulse and momentum. Plane motion of a rigid body. PREREQUISITE: ME 2501.

ME 2601 Mechanics of Solids (3-2).
Stress, strain, Hooke's law. Elementary stress and deformation analysis for shafts, beams and columns. Supporting laboratory work. PREREQUISITES: ME 2501 and MA 1116.

Upper Division or Graduate Courses

ME 3003 Energy and the Environment (3-0).
Principles of energy technology. Supply and demand. Survey of resources including coal, oil, gas, and uranium fuels. Solar energy utilization. Energy conversion schemes. Conservation efforts in the Navy. Effect of energy utilization upon the environment. This is an elective course for non-M.E. majors.

ME 3150 Heat Transfer (4-2).
Elementary treatment of the principles of Heat Transfer application to problems in Mechanical Engineering. Steady and unsteady conduction. Principles of forced and natural convection. Thermal radiation. Boiling. Condensation. Heat exchanger analysis. Use of the thermal circuit analog numerical and graphical techniques. Selected laboratory experiments. PREREQUISITES: ME 2101, ME 2201, MA 3132 (may be taken concurrently).

ME 3201 Intermediate Fluid Mechanics (3-2).
Steady one-dimensional compressible flow. Fundamentals of ideal-fluid flow, potential function, stream function. Analysis of viscous flows, velocity distribution in laminar and turbulent flows, introduction to the elements of the Navier-Stokes equations, solution of classical viscous laminar flow problems. Boundary-layer concepts. PREREQUISITES: ME 2101, ME 2201, MA 3132 (may be taken concurrently).

ME 3220 Steam Power, Refrigeration, and Turbomachinery (3-2).
The conventional Rankine cycle steam plants, including superheat, reheat, and regenerative cycles. Boiler, condenser, and feed-water heater description. Thermodynamics of refrigeration systems. Fundamentals of turbomachinery: energy and momentum equations, dimensional analysis, and velocity diagrams. Application to pumps, fans, compressors, and turbines. PREREQUISITES: ME 2101 and ME 2201.

ME 3230 Nuclear Power Systems (4-0).
Fundamentals of nuclear reactor analysis, including nuclear and thermal aspects in core design. Reactor system design and operation. Comparison of principal reactor types emphasizing significant features of marine reactors. Basic health physics considerations and reactor shielding. Basic insight into waste management and reactor safety. Integrated plant operations and casualty response. PREREQUISITE: ME 3150.

ME 3240 Reciprocating and Gas Turbine Power Plants (3-0).
Thermodynamic analyses and performance characteristics of spark ignition engines (Otto Cycle), compression ignition engines (diesel cycle), and gas turbine engines (Brayton cycle). Gas turbine component characteristics including the aerodynamics of the compressor and turbine design, and the combustor. Ship propulsion requirements, propeller characteristics, and Ship/Propeller/Power Plant matching. PREREQUISITES: ME 3220. (ME 3241 must be taken concurrently.)

ME 3241 Power Plants Laboratory (0-3).
Selected experiments demonstrating power plant performance, e.g., diesel engine, and gas turbine engine. (ME 3240 must be taken concurrently.) *Graded on Pass/Fail basis only.*

ME 3430 Mechanical Engineering Lab II (1-3).
A project-oriented continuation of mechanical measurement systems. Application of measurement techniques using group projects in thermodynamics, mechanics of solids, heat transfer, fluid flow, vibrations and nuclear radiation detection. PREREQUISITES: ME 2410, ME 3150, ME 3521, and ME 3611. *Graded on Pass/Fail basis only.*

ME 3440 Engineering Systems Analysis (4-0).
The purpose of this course is to show the similarities of engineering problems arising from a variety of disciplines. After problems are classified, various methods of solutions are reviewed and studied. For the numerical solutions of problems, students are introduced to the computer facilities of the school. Whenever possible, students are strongly encouraged to solve problems using a variety of computer languages. FORTRAN and BASIC are emphasized. The use of programmable personal calculators is strongly encouraged. PREREQUISITES: ME 2101, ME 2201, ME 2502, and ME 2601.

ME 3521 Mechanical Vibration (3-2).
Free and forced vibration of discrete linear systems. Vibration isolation and suppression. Vibration of bars, shafts, and beams. Supporting laboratory work. PREREQUISITES: ME 2502, ME 2601, and MA 2401 or equivalent (may be taken concurrently).

ME 3611 Mechanics of Solids II (4-0).
Fundamentals of elasticity. Failure theories. Energy methods. Indeterminate structures. Stability of simple structures. Torsion of members with non-circular cross section. Plate behavior. PREREQUISITES: ME 2501, ME 2601, and MA 2401 or equivalent (may be taken concurrently).

ME 3711 Design of Machine Elements (4-1).
Design of representative machine elements with consideration given to materials selection, tolerances, stress concentrations, fatigue, factors of safety, reliability, and maintainability. Typical elements to be designed include fasteners, columns, shafts, journal bearings, spur and helical gears, and clutches and brakes. In addition to traditional design using factors of safety against failure, particular emphasis is placed on design for specified reliability using probabilistic design methods. PREREQUISITES: ME 2410 and ME 2601.

Graduate Courses

ME 4160 Applications of Heat Transfer (4-0).
Application of heat transfer principles to engineering systems. Topics include heat exchangers (e.g., boilers, condensers, coolers), cooling electronic components, heat pipes, solar collectors, turbine blade cooling. PREREQUISITE: ME 3150.

ME 4161 Conduction and Radiation Heat Transfer (4-0).
Steady-state heat conduction in multi-dimensions with and without heat sources. Transient conduction. Numerical methods for heat conduction. Variational methods. Mechanical Engineering applications. Black body radiation; radiation from real surfaces; radiation exchange between finite surfaces. The network method, radiation through participating media. PREREQUISITE: ME 3150.

ME 4162 Convection Heat Transfer (4-0).
Fundamental principles of forced and free convection. Dimensionless correlations. Heat transfer during phase changes. Combined conduction, convection and radiation heat transfer systems. Heat exchanger analysis with Mechanical Engineering applications. PREREQUISITES: ME 3150, ME 4220 (may be taken concurrently).

ME 4211 Hydrodynamics (4-0).
Fundamental principles of hydrodynamics. Brief review of the equations of motion and types of fluid motion. Standard potential flows: source, sink, doublet, and vortex motion. Flow about two-dimensional bodies. Flow about axisymmetric bodies. Added mass of various bodies and the added-mass moment of inertia. Complex variables approach to flow about two-dimensional bodies. Conformal transformations. Flow about hydro- and aerofoils. Special topics such as dynamic response of submerged bodies, hydroelastic oscillations, etc.. Course emphasizes the use of various numerical techniques and the relationship between the predictions of hydrodynamics and viscous flow methods. PREREQUISITE: ME 3201.

ME 4215 Dynamics of Marine Vehicles (4-0).
Development of the equations of motion and their linear forms. Elements of path keeping and stability for ships and submersibles. Maneuverability. Fluid-structure interactions due to buoyancy, resistance, and propulsion. Hydrodynamics of lifting surfaces. Calculation of the hydrodynamic derivatives. Selected topics. PREREQUISITE: ME 3201.

ME 4220 Viscous Flow (4-0).
Development of continuity and Navier-Stokes equations. Exact solutions of steady and unsteady viscous flow problems. Development of the boundary-layer equations. Similarity variables, numerical and integral techniques. Separation, boundary-layer control, compressibility effects. Time-dependent boundary layers. Origin and nature of turbulence, phenomenological theories, calculation of turbulent flows with emphasis on naval engineering applications. PREREQUISITE: ME 3201.

ME 4240 Advanced Topics in Fluid Dynamics (4-0).
Topics selected in accordance with the current interests of the students and faculty. Examples include fluid-structure interactions, cable strumming, wave forces on structures, free-streamline analysis of jets, wakes, and cavities. PREREQUISITES: ME 4220 and ME 4211 or ME 4215.

ME 4311 Nuclear Reactor Analysis (4-0).
Neutron cross sections. The fission process. Neutron transport. Slowing down and diffusion of neutrons. Criticality analysis of bare, homogeneous reactors. The influence of reflectors. Reactor kinetics and control. PREREQUISITES: ME 3230 or equivalent, MA 3132.

ME 4321 Reactor Engineering Principles and Design (4-2).
Reactor heat generation and removal. Thermal hydraulic analysis of light water reactors. Principles of reactor shielding. Materials and safety considerations in reactor design. Group design project. PREREQUISITE: ME 3230 or equivalent.

ME 4420 Marine Gas Turbines (4-0).
Thermodynamic analyses of gas turbine cycles, including airbreathing and closed cycle engines. Internal aerodynamics of compressor and turbine design. Combustor and source heat exchanger design. Materials considerations. Operational controls and instrumentation. Lubrication and fuels systems. Inlet, exhaust, and silencing systems. Propulsion of surface effect, hydrofoil, and conventional surface effect, hydrofoil, and conventional surface ships. Installation arrangements. Waste heat recovery systems and combined cycles (COGAS, CODOG). Auxiliary power generation. Repair and maintenance. PREREQUISITE: ME 3240.

ME 4512 Advanced Dynamics (4-0).
Three-dimensional kinematics. The inertia tensor. Dyadic-vector formulation of dynamical equations. Topics of special interest. PREREQUISITE: ME 3521.

ME 4522 Vibration, Noise, and Shock (4-0).
Matrix analysis of many degree of freedom systems. Discrete models of continuous systems. Transfer matrices. Applications to shipboard vibration and noise control. Shock response analysis. PREREQUISITE: ME 3521.

ME 4612 Advanced Mechanics of Solids (4-0).
Selected topics from advanced strength of materials, elasticity, and the theory of plates and shells. Applications of finite element codes to the solution of difficult problems. PREREQUISITE: ME 3611.

ME 4613 Finite Element Methods (4-0).
Systematic construction of line, surface, and volume elements for continuous systems. Computer programming, and applications to structural mechanics, heat transfer and fluid flow. PREREQUISITE: ME 3611.

ME 4620 Theory of Continuous Media (4-0).
Tensor analysis. Stress and strain tensors. Motion of a continuum. Energy and entropy. Constitutive equations. Applications to elasticity and fluid dynamics. PREREQUISITES: ME 3201 and ME 3611.

ME 4721 Marine Vehicle Design (2-4).
Various categories of marine vehicles are described; this includes single hull, multiple hull, submarine, surface effect, wing-in-ground effect and hydrofoil vehicles. A category of marine vehicle is selected to fulfill a stated mission. A vehicle configuration and specification of major components which satisfies mission requirements is sought. Consideration is given to all major facets of marine vehicle synthesis including structures, hull forces, propulsion, electronics, armament, crew, etc. PREREQUISITE: Consent of Instructor.

ME 4722 Marine Engineering Design (2-4).
A major component of a marine vehicle is designed so as to meet stated specifications. Impact of the design features of the major component upon the overall vehicle performance is considered; emphasis is on design tradeoffs. Examples of major components to be designed include complete electrical power generation and distribution system, steering, superconducting electrical motors for main propulsion, bulbous bow for sonar, armor protection of CIC, etc. PREREQUISITE: Consent of Instructor.

ME 4731 Engineering Design Optimization (4-0).
Application of automated numerical optimization techniques to design of engineering systems. Algorithms for solution of nonlinear constrained design problems. Familiarization with available design optimization programs. State-of-the-art applications. Solution of a variety of design problems in mechanical engineering, using numerical optimization techniques. PREREQUISITES: ME 3150, ME 3201, ME 3611, CS 2700, or equivalent, and MA 2400, or equivalent.

ME 4801 Fluid Power Control (3-2).
Fluids and fluid flows in hydraulic systems. Analysis of pumps, motors, and control valves. Analytical methods in fluid power control systems. Hydraulic power elements. Electrohydraulic servovalves. Electrohydraulic and hydromechanical servomechanisms. Selected topics. PREREQUISITE: EE 3413 or equivalent.

ME 4802 Marine Propulsion Control Systems (3-2).
Fundamental characteristics of electropneumatic and electro-hydraulic control systems operational in both steam turbine and gas turbine powered ships. Systems analysis — controllability and stability. System design using model techniques. PREREQUISITES: ME 3201, EE 3413, and ME 3240 (may be taken concurrently).

ME 4902 Advanced Study in Mechanical Engineering (1-0 to 6-0).
Directed advanced study in mechanical engineering on a subject of mutual interest to student and staff member. May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman. *Graded on Pass/Fail basis only.*

MATERIALS

Upper Division Course

MS 2201 Engineering Materials (3-2).
Fundamental principles of materials science are presented with particular emphasis on mechanical behavior. The effects of atomic structure, crystal structure, and microstructure on properties of structural materials are emphasized. Crystalline defects, deformation processes, strengthening mechanisms, brittle fracture, phase equilibria, heat treatment, and microstructural control are discussed with reference to practical examples. The course aims at providing the Naval Engineering student with the vocabulary and conceptual understanding necessary for further study or for communicating with materials experts. PREREQUISITE: Elementary courses in physics and chemistry.

Upper Division or Graduate Courses

MS 3201 Materials Science and Engineering (3-2).
Intended as a first course in materials for students who have had an undergraduate survey course in materials (such as MS 2201), or who have a good background in chemistry, thermodynamics, and physics. Fundamental principles of materials science are presented with particular emphasis on mechanical behavior. Topics covered include atomic structure, crystal structure, microstructure, crystalline defects, deformation processes, strengthening mechanisms, fracture, and phase transformations. PREREQUISITE: Undergraduate course in materials, and/or courses in chemistry, thermodynamics and physics.

MS 3202 Properties, Problems, and Failures of Structural Materials (3-2).
Topics of interest to the Naval, Aero, or Weapons engineer are emphasized through case studies of actual failures. The cause(s) of each failure are presented, and the necessary background material to fully understand the phenomena is then provided in each case. Failures due to fatigue, brittle fracture, corrosion, and fabrication deficiencies are among those discussed. Selection of materials and modern methods of materials analysis are treated. PREREQUISITE: MS 2201 or equivalent or permission of Instructor.

MS 3206 Imperfections in Crystalline Solids (3-0).
The effects of crystalline defects on the physical and mechanical behavior of solids are discussed. This course examines in moderate detail those microstructural features which have a major impact on materials development, fabrication, and utilization. Example topics are point defects in electronics, materials, strain-aging phenomena, the role of stacking faults in material failure, and subgrain strengthening. PREREQUISITE: MS 2201 or equivalent.

MS 3304 Corrosion and Marine Environmental Degradation (3-2).
Presents the basic chemical, electrochemical, mechanical, and metallurgical factors which influence the corrosion, oxidation, and deterioration of materials. Discusses standard methods of corrosion control, such as cathodic protection coatings, cladding, alloy selection, and inhibitors; special problems encountered in unfamiliar environment. PREREQUISITE: MS 2201 or equivalent.

MS 3305 Materials for Electrical and Electronic Applications (3-0).
The materials used in electrical and electronic applications are discussed, including ferromagnetic and ferri-magnetic materials, semi-conductors, insulators, dielectrics, and piezoelectric and ferroelectric crystals. The electronic, crystallographic and thermodynamic principles controlling these materials are discussed and the heat treatments, compositions, and methods of fabrication of commercial materials are emphasized. PREREQUISITE: Consent of Instructor.

MS 3401 Microscopy (3-2).
Electron microscopy and other sophisticated techniques are emphasized in a coverage of modern methods of microscopic observation. Techniques covered include scanning electron microscopy, transmission electron microscopy, conventional microprobe analysis, field ion microscopy, and polarized light, stereo, interference, phase contrast, and holographic light optical methods. Course and lab will simultaneously cover both theory and practice, including specimen preparation, instrument design and operation, and applications, PREREQUISITE: Consent of Instructor.

MS 3505 Materials Selection for Military Applications (4-0).
This course deals in depth with one of the most common and important problems in materials engineering, that of selecting the optimum material for a given application. Consideration is also given to evolution of new applications for existing materials, and to materials development for new and old applications. A variety of application areas are covered, including marine structures, aerospace applications, nuclear reactors, electronics, high temperature cryogenic services, and many other situations. Sources of information, methodology, and basic rationale for materials selection decisions are presented. Emphasis is put on the variation in properties of a given material with processing history, and on variation of properties in service. PREREQUISITE: MS 2201 or equivalent.

MS 3606 Introduction to Welding and Joining Metallurgy (3-2).
Metallurgical aspects of welding and joining processes; nature of and applications of welding and joining processes; welding and joining of steels, aluminum alloys, stainless steels, heat-resistant alloys and copper-base alloys; inspection and quality assurance of weldments. PREREQUISITE: MS 2201/3201.

Graduate Courses

MS 4215 Phase Transformations (3-2).
Structural changes which commonly occur in materials by various mechanisms are considered. Solidification, precipitation, recrystallization, and martensitic transformations are emphasized, both in principle and in regard to their technological importance. Principles of nucleation and growth, diffusion and kinetics are presented and their relevance to practical heat treating and fabrication processes are considered. PREREQUISITE: MS 2201 or equivalent.

MS 4302 Special Topics in Materials Science (1-0 to 6-0).
Directed advanced study in materials science on a subject of mutual interest to student and staff member. May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman. *Graded on Pass/Fail basis only.*

MS 4312 Advanced Materials (4-0).
The course is structured to provide a vehicle for the study of materials pertinent to a specific area of environment utilization or design. Example categories are marine materials, nuclear materials, elevated-temperature materials, aircraft alloys, materials for energy conversion. Topics discussed may include material failures, materials selection, testing, and new concepts in materials engineering. Course scope is decided by mutual agreement of students and Instructor. PREREQUISITES: MS 2201, MS 3202, or equivalent.

MS 4811 Mechanical Behavior of Engineering Materials (3-2).
The response of structural materials to mechanical stress is discussed with emphasis on plastic deformation in metals. Topics include mechanisms of high-temperature deformation, fatigue, and fracture. New concepts allowing development of materials to circumvent these failure mechanisms are treated. PREREQUISITES: MS 3202 or permission of Instructor.

DEPARTMENT OF METEOROLOGY

Instructing Air-Ocean student on the operation of the Navy Environmental Display Station

Robert Joseph Renard, Professor of Meteorology; Chairman (1952)*; M.S., Univ. of Chicago, 1952; Ph.D., Florida State Univ., 1970.

James Stephen Boyle, NRC Research Associate (1981); B.S., Iona College, 1968; M.S., State Univ. of New York at Albany, 1975; Ph.D., 1980.

Joost Alois Businger, Research Chair Professor (1980); B.S., Univ. of Utrecht, 1947; Ph.D., 1954.

Chih-Pei Chang, Associate Professor of Meteorology (1972); B.S., National Taiwan Univ., 1966; Ph.D., Univ. of Washington, 1972.

Lang Chiu Chou, Adjunct Research Instructor (1977); B.S., Tunghai Univ., 1968; M.S., Univ. of Washington, 1977.

Kenneth La Vern Davidson, Associate Professor of Meteorology (1970); B.S., Univ. of Minnesota, 1962; M.S., Univ. of Michigan, 1966; Ph.D., 1970.

Russell Leonard Elsberry, Professor of Meteorology (1968); B.S., Colorado State Univ., 1963; Ph.D., 1968.

Patrick Charles Gallacher, Adjunct Research Instructor (1978); B.S., Xavier Univ., 1972; M.S. in Physics, Univ. of Cincinnati, 1974; M.S. in Oceanography, Oregon State Univ., 1978.

Robert Lee Haney, Associate Professor of Meteorology (1970); A.B., George Washington Univ., 1964; Ph.D., Univ. of California at Los Angeles, 1971.

Hock Lim, Visiting Assistant Professor of Meteorology (1980); B.S., Univ. of Singapore, 1970; Ph.D., Reading Univ. 1975.

Mary Alice Rennick, Adjunct Assistant Professor of Meteorology (1981); B.S., Knox College, 1970; M.S., Univ. of Illinois, 1972; Ph.D., 1975.

Kshudiram Saha, NRC Senior Research Associate (1980); B.S., Univ. of Allahabad, 1938; M.S., 1940; Ph.D., Univ. of Calcutta, 1956.

Willem van der Bijl, Associate Professor of Meteorology (1961); B.Sc., Free Univ. of Amsterdam, 1941; M.Sc., 1943; Ph.D., State Univ. Utrecht, 1952.

Carlyle Hilton Wash, Assistant Professor of Meteorology (1980); B.S., Univ. of Wisconsin, 1969; M.S., 1975; Ph.D., 1978.

Forrest Roger Williams, Commander, U.S. Navy; Assistant Professor of Meteorology (1974); B.S., Naval Academy, 1956; M.S., Naval Postgraduate School, 1962; M.S., Massachusetts Institute of Technology, 1972.

Roger Terry Williams, Professor of Meteorology (1968); A.B., Univ. of California at Los Angeles, 1959; M.A., 1961; Ph.D., 1963.

Emeritus Faculty

William Dwight Duthie, Distinguished Professor Emeritus (1945); B.A., Univ. of Washington, 1935; M.S., 1937; Ph.D., Princeton Univ., 1940.

George Joseph Haltiner, Distinguished Professor Emeritus (1946); B.S., College of St. Thomas, 1940; Ph.M., Univ of Wisconsin, 1942; Ph.D., 1948.

Frank Lionel Martin, Professor Emeritus (1947); B.A., Univ. of British Columbia, 1936; M.A., 1938; Ph.D., Univ. of Chicago, 1941.

**The year of joining the Postgraduate School faculty is indicated in parentheses.*

DEPARTMENT REQUIREMENTS FOR DEGREES IN METEOROLOGY OR METEOROLOGY AND OCEANOGRAPHY

MASTER OF SCIENCE IN METEOROLOGY

1. Entrance to a program leading to a Master of Science degree in Meteorology requires mathematics through differential and integral calculus and a minimum of one year of college physics.

2. The degree of Master of Science in Meteorology requires completion of:

a. Mathematics courses in vector analysis, partial differential equations, and application of numerical methods and computers to the solution of partial differential equations.

b. Thirty-five quarter hours of graduate meteorology courses of which 15 hours must be in the 4000 series.

c. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology must be included in these 35 hours.

d. An acceptable thesis.

MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

1. Direct entrance to a program leading to the degree Master of Science in Meteorology and Oceanography requires a baccalaureate degree in meteorology and/or oceanography or equivalent. This normally permits the validation of required undergraduate courses such as physics, chemistry, differential equations, linear algebra, vector analysis and various courses in meteorology and/or oceanography, which are prerequisites to the graduate program. These prerequisites may be taken at the

Naval Postgraduate School; however, in that event the program may be lengthened by one or two quarters.

2. The degree of Master of Science in Meteorology and Oceanography requires:

   a. Completion of 48 quarter hours of graduate courses in meteorology and oceanography including MR/OC 4413, MR 4322, MR/OC 4323 and 10 quarter hours in the 4000 oceanography series. The degree program must be approved by both the Department of Meteorology and the Department of Oceanography.

   b. Completion of an acceptable thesis on a topic approved by either department.

DOCTOR OF PHILOSOPHY

The Ph.D. Program is offered in the Department of Meteorology in the following areas of study: numerical weather prediction, geophysical fluid dynamics, analysis of atmospheric systems, and tropical meteorology.

The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation, and examination in both the major and a minor field. The minor field is usually in oceanography, mathematics or physics.

The required examinations are described in this catalog in the section Requirements for the Doctor's Degree. The Department of Meteorology may also require a preliminary examination in order to show evidence of acceptability as a doctoral student.

Prospective students should consult with the Chairman of the Department of Meteorology for further guidance regarding doctoral programs.

METEOROLOGICAL LABORATORIES

In addition to the standard synoptic laboratories, NPS meteorological facilities include most instruments in present-day use for observing the atmosphere as well as equipment for copying weather analyses and forecasts emanating from the National Weather Service. Similar information is received from Fleet Numerical Oceanography Center in Monterey. The Naval Environmental Display Station is scheduled to be installed in FY 1982. Rawinsonde and wiresonde equipment, an acoustic sounder, an APT receiver for readout of weather satellite data and micrometeorologically instrumented masts on the Research Vessel ACANIA are utilized by faculty and students in the Meteorology and Oceanography Programs.

DEPARTMENTAL COURSE OFFERINGS

MR 0110-11-12 Applications Seminars (1-0).
Presentation of DOD related research activities, applications to weapons and warfare systems, utilization of oceanography and meteorology in specific billets, presentations by faculty, staff, selected students and visiting authorities. MR 0110 is for orientation; MR 0111 is for beginning students; MR 0112 is for advanced students. PREREQUISITE: Enrollment in an Air-Ocean Science curriculum.

MR 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

MR 0999 Seminar in Meteorology (2-0).
Students present results of thesis or other approved research investigation. PREREQUISITE: Concurrent preparation of thesis or other acceptable research paper.

Upper Division Courses

MR 2200 Introduction to Meteorology (4-0).
An introductory course that treats the composition and structure of the atmosphere, thermodynamic processes, forces and related small- and large-scale motions, air masses, fronts, severe storms, solar and terrestrial radiation, general circulations and weather forecasting. PREREQUISITE: Department approval. *(May be taken through Continuing Education as minicourses MR 2201-02.)*

MR 2210 Introduction to Meteorology/ Laboratory (4-2).
Same course as MR 2200 plus laboratory periods illustrating lecture material, including weather map analysis over oceanic areas using satellite imagery. PREREQUISITE: Department approval.

MR 2413 Meteorology for Antisubmarine Warfare (3-0).
A general course in meteorology for the ASW curriculum. Atmospheric stability and EM wave propagation are related to vertical distributions of temperature and moisture; changes in the ocean mixed layer depth are related to boundary fluxes. PREREQUISITES: Differential and integral calculus concurrently.

MR 2416 Meteorology for Electronic Warfare (2-0).
A survey of environment factors affecting the propagation and attenuation of electromagnetic (EM) and optical (EO) waves in the atmosphere; vertical distributions of temperature and moisture in the marine atmosphere; synoptic conditions associated with anomalous propagation of electromagnetic waves; regions and layers associated with high aerosol concentrations and turbulence intensities affecting optical wave propagation. PREREQUISITES: Calculus; Computer Programming; Electromagnetic Theory concurrently.

Upper Division or Graduate Courses

MR 3140 Probability and Statistics for Air-Ocean Science (2-2).
Basic probability and statistics, in the air-ocean science context. Techniques of statistical data analysis. Structure of a probability model, density, distribution function, expectation and variance. Binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and central limit theorem. Transformations of random variables. Histograms and empirical distributions and associated characteristics such as moments and percentiles. Standard tests of hyupotheses and confidence intervals for both one and two parameter situations. Regression analysis as related to least squares estimation. TI-59 competence. PREREQUISITE: Calculus.

MR. 3150 Air-Ocean Data Networks (3-2).
Analysis methods for atmospheric and oceanic time series. Correlation, spectrum, and empirical orthogonal function analyses. Statistical objective analysis. Optimal design of air-ocean data networks. PREREQUISITES: MA 2121, and a probability and statistics course.

MR 3212 Polar Meteorology/Oceanography (3-1).
Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea-ice; its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Aspects of geology and geophysics. PREREQUISITES: OC 3221, MR 3222 or consent of Instructor.

MR 3220 Meteorological Analysis (4-0).
Techniques of evaluation, interpretation and analysis of pressure, wind, temperature, and moisture data, including weather satellite observations, with emphasis on the low and middle troposphere. Synoptic models of extratropical vortices, waves and frontal systems, with emphasis on three dimensional space structure and time continuity. Introduction to analysis in the high troposphere and low stratosphere. PREREQUISITES: MR 3420, MR/OC 3321 concurrently.

MR 3222 Meteorological Analysis/ Laboratory (4-3).
Same as MR 3220 plus laboratory sessions on the concepts considered in the lecture sessions with emphasis on the analysis of the low and middle troposphere, especially surface and 500 mb charts and associated vertical cross sections. PREREQUISITES: MR 3420, MR/OC 3321 concurrently.

MR 3230 Tropospheric and Stratospheric Meteorology (4-0).
An analytic and synoptic interpretation of tropospheric and stratospheric systems with emphasis on the middle and high altitude aspects of extratropical cyclones, jet streams and fronts, and related dynamical properties. PREREQUISITES: MR 3220 or MR 3222, MR 4322 concurrently.

MR 3235 Tropospheric and Stratospheric Meteorology Laboratory (0-7).
Practice in synoptic-scale analysis of parameters considered in MR 3230 with emphasis on objectivity, interrelationships and application to diagnostic problems. PREREQUISITES: MR 3222, MR 3230 concurrently.

MR 3240 Operational Environmental Products (0-2).
Meteorological products available to the operating fleet from Fleet Numerical Oceanography Center/Naval Oceanography Command Centers and other sources are described and applied to the analysis and forecasting of tactical environmental parameters for both current and historical situations. PREREQUISITE: MR 2210 or consent of Instructor.

MR 3250 Tropical Meteorology (3-0).
Structure and development of tropical cyclones; observations of synoptic-scale wave disturbances, cloud clusters, upper tropospheric systems, the intertropical convergence zone and monsoon circulations; tropical scale analysis and energetics. PREREQUISITES: MR 4322, MR 3220 or MR 3222.

MR 3252 Tropical Meteorology/Laboratory (3-4).
Same as MR 3250 plus laboratory sessions on streamline, isotach, and contour (isobaric) analyses and forecasting of tropical systems, with emphasis on tropical cyclones and the use of meteorological satellite observations. PREREQUISITES: MR 3222, MR 4322, and MR 3420.

MR 3260 Prognostic Charts and Forecasting Weather Elements (3-0).
Subjective and objective methods of atmospheric prognosis and techniques for forecasting operationally-important weather elements from surface to 10 mb. Interpretation, use and systematic errors of computer-generated products. Weather satellite briefs and applications of forecasting principles to current situations. PREREQUISITES: MR 3230, MR/OC 4323 or consent of Instructor.

MR 3262 Prognostic Charts and Forecasting Weather Elements/Laboratory (3-3).
Same as MR 3260 plus laboratory sessions on the application of lecture material. Also practice in weather briefing, including diagnosis and forecasting of current weather situations using weather satellite observations and National Meteorological Center and Fleet Numerical Oceanography Center products. PREREQUISITES: MR 3230, MR/OC 4323 or consent of Instructor.

MR 3321 Air-Ocean Fluid Dynamics (4-0).
The hydrodynamical equations for a rotating fluid. Forces, kinematics, simple balanced flows, barotropy, baroclinicity, vertical shear, various vertical coordinates. Friction and boundary layers, introduction to scale analysis. Vorticity and divergence equations. PREREQUISITES: MA 2047, MA 2121 (may be concurrent), or equivalent.

MR 3420 Geophysical Thermodynamics (4-0).
The physical variables; properties of gases, water and moist air; equations of state and the laws of thermodynamics applied to the atmosphere and oceans; entropy, adiabatic processes and potential temperatures; meteorological thermodynamic diagrams; geopotential and hydrostatic equilibrium, stability criteria and condensation levels. PREREQUISITE: MA 1116 or equivalent. *(May be taken through Continuing Education as minicourses MR 3418-19.)*

MR 3421 Cloud Physics (3-0).
Basic principles of cloud and precipitation physics and application to weather modification. Selected topics in atmospheric pollution. PREREQUISITE: MR 3420.

MR 3512 Heat Transfer Processes (4-0).
Monochromatic intensity and flux from black bodies; other properties of black bodies. The flux of infrared radiation crossing an arbitrary level in an atmosphere consisting both of water vapor and carbon dioxide. Infrared flux-divergence as a cooling effect in the atmosphere. Insolation at the outer boundary of the atmosphere and at the earth; parameterization of solar attenuation processes in the atmosphere. The mean heat balance of the earth and atmosphere. Net radiative energy as a driving mechanism for the general circulation. PREREQUISITE: MR 3420 or consent of Instructor.

Graduate Courses

MR 4241 Mesoscale Meteorology (3-0).
Descriptive and physical understanding of subsynoptic scale weather systems and their relation to the synoptic-scale environment. Applications to short-range and local-area forecasting utilizing satellite and numerical-model products relevant to mesoscale weather phenomena. PREREQUISITES: MR 3230; MR/OC 4323, or MR 4322 with consent of Instructor.

MR 4242 Advanced Tropical Meteorology (3-0).
Equatorial wave theory; stratospheric wave motions and quasi-biennial oscillations; tropospheric disturbances; energy sources and instabilities; boundary layer and cumulus convection parameterization; monsoon circulations and their interactions with other scales; Tropical cyclone models; use of satellite data; and selected topics in dynamics and thermodynamics of tropical flows. PREREQUISITE: Consent of Instructor.

MR 4250 General Circulation of the Atmosphere and Oceans (3-0).
Selected topics on the general circulation of the atmosphere (e.g., heat, momentum and moisture fluxes; energetics) and ocean (e.g., linear and nonlinear theories of the wind-driven ocean circulation, nonlinear thermocline theories, mesoscale eddies, mixed-layer theories); coupled ocean-atmosphere general circulation models. PREREQUISITE: Consent of Instructor.

MR 4322 Dynamic Meteorology (4-0).
Scale analysis, perturbation method; solutions of equations of motion for sound, gravity, and synoptic waves; baroclinic and barotropic instability; energetics; geostrophic adjustment. PREREQUISITE: MR 3420, MR/OC 3321, MA 3132 or equivalent.

MR 4323 Numerical Air and Ocean Modeling (4-3).
Numerical models of meteorological and oceanographic phenomena. Finite difference techniques for solving elliptic and hyperbolic equations, linear and nonlinear computational instability. Barotropic and primitive equation prediction models. Sigma coordinate. Objective analysis and initialization. Moisture and heating as time permits. PREREQUISITES: MR 4322, MA 3232 desirable.

MR 4324 Advanced Numerical Weather Prediction (3-0).
Initialization, boundary conditions; sensible, latent, and radiative heat transfer, simulation of sub-grid scale processes such as convection and friction; general circulation models, spectral methods. PREREQUISITE: MR/OC 4323 or consent of Instructor.

MR 4331 Advanced Geophysical Fluid Dyamics I (3-0).
Advanced topics in the dynamics of the atmosphere and the oceans including scale analysis; geostrophic adjustment; dispersion, and barotropic and baroclinic instabilities. PREREQUISITE: Consent of Instructor.

MR 4332 Advanced Geophysical Fluid Dynamics II (3-0).
Energetics of unstable disturbances; frontogenesis; boundary layer analysis with application to the Ekman layer and to the frictional and the nonlinear ocean boundary currents; finite amplitude baroclinic waves. PREREQUISITE: Consent of Instructor.

MR 4413 Air/Sea Interaction (4-0).
Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface and Ekman layers, and bulk formulae for estimating air-sea fluxes. The oceanic planetary boundary layer including the dynamics of the well-mixed surface layer. Recent papers on large-scale air-sea interaction. PREREQUISITE: MR 4322 or consent of Instructor.

MR 4414 Advanced Air/Sea Interaction (3-0).
Advanced topics in the dynamics of the atmospheric and oceanic planetary boundary layers. PREREQUISITE: MR/OC 4413 or consent of Instructor.

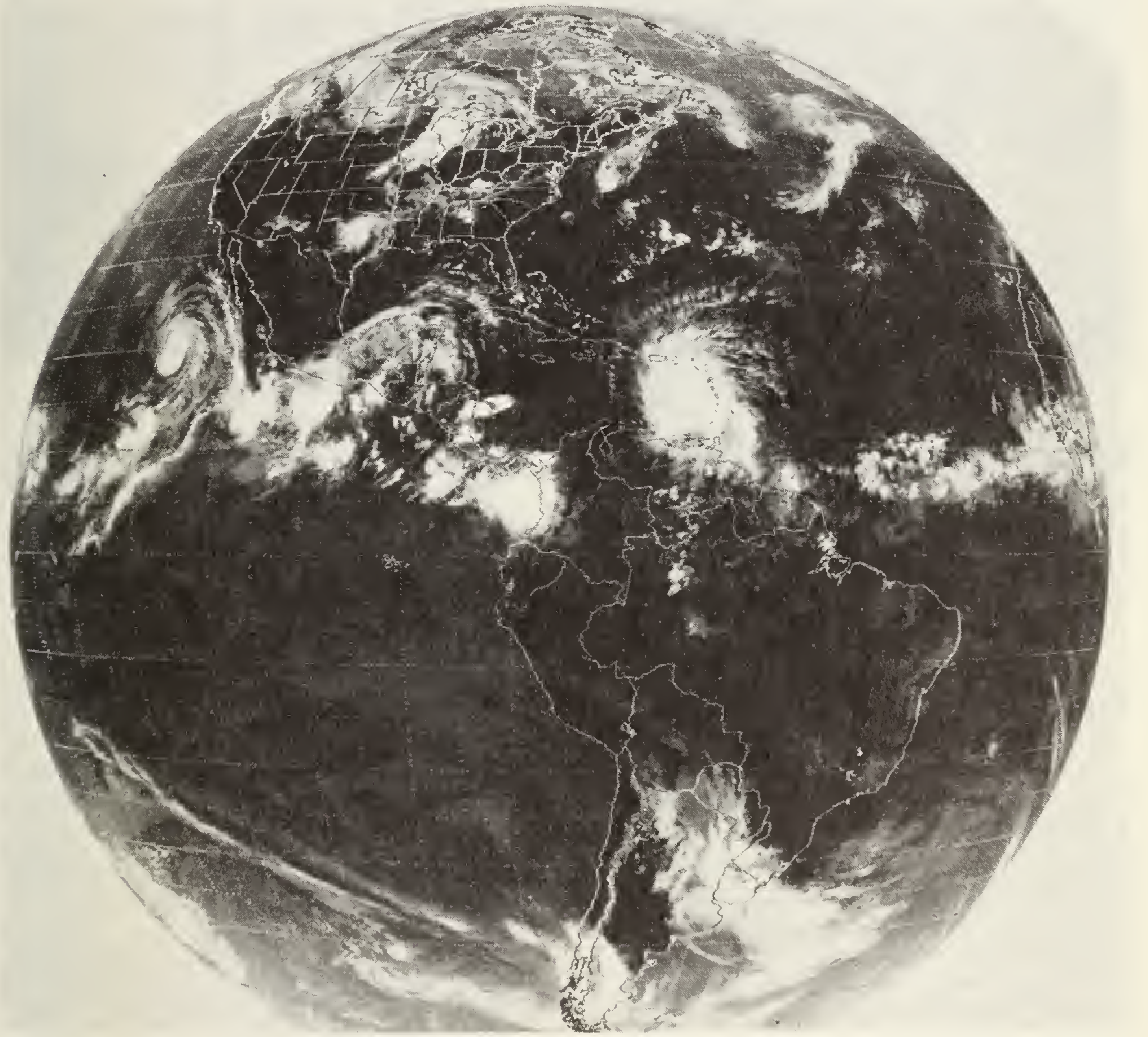
MR 4416 Atmospheric Factors in Electromagnetic and Optical Propagation (4-0).
Principles of microwave and optical wave propagation in the atmosphere. Effects of atmosphere on propagation; refraction, scattering, attenuation, ducting, etc. PREREQUISITE: MR/OC 4413, or consent of Instructor.

MR 4417 Topics in Remote Sensing and Satellite Observations (3-0).
Basic concepts of remote sensing with emphasis on satellites. Sensing meteorological

and other geophysical parameters. Regions of the electromagnetic spectrum suitable for sensing. Instrumentation; mathematical models of the pertinent radiative processes and methods of solution. Selected topics in analysis and interpretation of satellite imagery. PREREQUISITE: MR 3512 or equivalent.

MR 4800 Advanced Analysis and Prediction (3-0).
Selected topics in geophysical fluid dynamics, advanced diagnostic and prognostic techniques including modeling, remote sensing, etc. The course may be repeated for credit as topics change. PREREQUISITE: Consent of Department Chairman.

MR 4900 Special Topics in Meteorology (1-0 to 4-0).
Directed study of selected areas of meteorology to meet the needs of the individual student. PREREQUISITE: Consent of Department Chairman. *Graded on Pass/Fail basis only.*



Infrared satellite image of Hurricane Allen

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

Discussion of National Security Affairs students in the Soviet, East European Seminar room

Sherman Wesley Blandin, Jr., Professor of Defense Management; Chairman (1968)*; B.S., U.S. Naval Academy, 1944; B.S., Georgia Institute of Technology, 1952; M.S., 1953; M.B.A., Univ. of Santa Clara, 1973; Ph.D., 1977.

John William Amos, II, Associate Professor of Political Science (1970); B.A., Occidental College, 1957; M.A., Univ. of California at Berkeley, 1962; Ph.D., 1972.

Claude Albert Buss, Adjunct Professor of Political Science and History (1976); B.A., Washington Missionary College, 1922; M.A., Susquehanna Univ., 1924; Ph.D., Univ. of Pennsylvania, 1927.

Michael William Clough, Adjunct Professor of Political Science (1979); B.A., Univ. of California at Santa Barbara, 1974; M.A., Univ. of California at Berkeley, 1976.

Donald Charles Daniel, Associate Professor of Political Science (1975); A.B., Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

Katherine Lydigsen Herbig, Adjunct Professor of National Security Affairs (1980); B.A., Knox College, 1968; M.A., Claremont Graduate School, 1972; Ph.D., 1977.

Boyd Francis Huff, Professor of Government and History (1958); B.A., Univ. of Washington, 1938; M.A., Brown Univ., 1941; Ph.D., Univ. of California at Berkeley, 1955.

Edward John Laurance, Associate Professor of Political Science (1972); B.S., U.S. Military Academy, 1960; M.A., Temple Univ., 1970; Ph.D., Univ. of Pennsylvania, 1973.

Robert Edward Looney, Adjunct Professor of National Security Affairs (1979); B.S., Univ. of California at Davis, 1963; Ph.D., 1969.

Ralph Harry Magnus, Assistant Professor of National Security Affairs (1976); A.B., Univ. of California at Berkeley, 1958; M.A., 1966; Ph.D., 1971.

Edward Allan Olsen, Adjunct Professor of National Security Affairs (1980); B.A., Univ. of California at Los Angeles, 1968; M.A., Univ. of California at Berkeley, 1970; Ph.D., The American Univ., 1974.

Patrick Johnston Parker, Professor of Economics (1974); M.B.A., Univ. of Chicago, 1955.

William Reese, Professor of Physics and Defense Technology (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

Ronald Graham Sherwin, Adjunct Professor of Political Science (1975); B.A., California State College at Long Beach, 1965; M.A., Univ. of Southern California, 1967; Ph.D., 1972.

Kamil Taha Said, Adjunct Professor of National Security Affairs (1975); B.A., Colorado State College, 1937; M.A., San Jose State College, 1967.

Russel Henry Stolfi, Associate Professor of History (1966); B.S., Stanford Univ., 1954; M.A., 1964; Ph.D., 1966.

Frank Michael Teti, Associate Professor of Political Science (1966); B.A., Los Angeles State College, 1960; M.A., 1962; Diploma, Institute of World Affairs, 1961; M.P.A., Syracuse Univ., 1972; Ph.D., 1966.

Jiri Valenta, Associate Professor of National Security Affairs (1976); Ing. Pol. Ek., Prague School of Economics, 1968; Ph.D., Johns Hopkins Univ., 1975.

Peter Cheng-Chao Wang, Associate Professor of Mathematics and National Security Affairs (1970); B.A., Pacific Lutheran Univ., 1961; M.A., Wayne State Univ., 1962; Ph.D., 1966.

David Scott Yost, Adjunct Professor of International Relations (1979); B.A., Univ. of Southern California, 1970; M.A., 1970; M.S., 1973; Ph.D., 1976.

**The year of joining the Postgraduate School faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE MASTER OF ARTS IN NATIONAL SECURITY AFFAIRS

1. The entrance requirement for these programs is a baccalaureate degree earned with above average academic performance. Applicants must demonstrate their aptitude for the specific curriculum option concerned, through either the Graduate Record Examination or the completion of undergraduate courses which meet the prerequisites for the courses offered in the option. Such applicants must have the approval of the Chairman, Department of National Security Affairs.

2. Degree Requirements:

Area Specialization, Politico-Military, and Strategic Planning Options

a. A minimum of 44 quarter hours of approved graduate study pertinent to the field of National Security Affairs, of which at least 16 units must be at the 4000 level.

b. Completion of an approved sequence of courses concentrating in either an area or functional specialty, including at least one 4000 level course in that specialty.

c. Successful completion of a comprehensive examination or an acceptable thesis in lieu thereof.

d. Language requirements, when applicable.

Intelligence Option

a. A minimum of 44 quarter hours of graduate work, of which at least 12 quarter hours must be at the 4000 level. At least 20 hours must be in the area of national security affairs.

b. Completion of graduate courses in at least three different academic disciplines, including a 4000 level course in at least two of these disciplines.

c. Completion of an acceptable thesis in addition to the 44 quarter hours of course work.

DEPARTMENTAL COURSE OFFERINGS

NS 0010 Seminar in Naval Intelligence (0-2).
A series of colloquium seminars in subjects bearing on Naval Intelligence. Seminars will be phased with the development of the curriculum.

NS 0011 Seminar in National Security Affairs (0-2).
A series of colloqium seminars in subjects bearing on National Security Affairs will be phased with the development of the curriculum.

NS 0810 Thesis Research (0-0).
Students conducting thesis research will enroll in this course.

NS 0811 Preparation for Comprehensive Examination (0-0).
Students preparing for comprehensive examinations will enroll in this course.

Lower Division Course

NS 1368 American Life and Institutions (3-0).
American political institutions and the political, social, economic, and cultural aspects of American Life. OPEN ONLY TO ALLIED OFFICERS. *Graded on Pass/Fail basis only.*

Upper Division or Graduate Courses

NS 3000 Perspectives on American Civilization (4-0).
This course, especially designed for the foreign area studies (attache) program, is an interdisciplinary study of American culture, involving the political, economic, social, philosophical and literary development of the Nation from 1789 to the present.

NS 3032 Modern Revolution and Political Terrorism (4-0).
Study of the general historical framework of modern revolution to include systematical analysis of the development of modern revolutionary situations. Examination of the more important revolutions of modern times, including study of the historical events, testing of the methods of systematic analysis, with emphasis on revolutionary tactics, e.g. political terrorism.

NS 3061 American National Security Policy (4-0).
An institutional and functional analysis of the national and international factors which shape U.S. defense policy. Attention in the course is focused on two major areas: 1) the decision-making process, including the legislative-executive budgetary process, as well as the influence of bureaucratic politics and interest group participation upon defense decisions; 2) the problems of strategic choice, including threat analysis, net assessment, deterrence theory, and limited war.

NS 3062 Intelligence Data Analysis and Research Methods (4-2).
A survey of methods and techniques for synthesis, analysis, interpretation, and reporting of data. Topics include sampling methods, content analysis, data handling and processing, scaling techniques, and parametric and non-parametric tests, with emphasis on application to intelligence. PREREQUISITES: OS 3101, MA 2311 or equivalent.

NS 3063 Intelligence and the Military (4-0).
An overview of the intelligence structure and a survey of the intelligence process focusing on the application of intelligence to the military mission. The organization and functions of the various elements of the intelligence community are presented. Primary emphasis is placed on the use of intelligence by military decision-makers. Included are overviews of systems supporting the collection, production and dissemination of intelligence. The course is intended for the non-intelligence specialist and is available to any student wishing to learn about the intelligence community and its ability to provide support to the military.

NS 3064 Intelligence Systems and Products (4-0).
This course is intended for students in the command and control program. It provides an introduction to intelligence systems and products which support command decision making, an overview of Soviet command and control concepts and practices required for an appreciation of the significance of intelligence reporting, an insight into intelligence procedures to provide perspective for operational security planning, and material on Soviet intelligence organizations and capabilities. PREREQUISITES: TOP SECRET clearance with eligibility for SI/SAO, U.S. Citizenship.

NS 3065 Strategic Planning and U.S. National Security Policy (4-0).
The focus of this course will be on long term Strategic Planning and will include such topics as: Strategic Goal Analysis, national and transnational power assessment, analysis of the decision making and administrative processes at the national level, indigenous constraints on the policy process, forecasting and future research techniques and the application of the concepts of strategic planning to the national defense effort. PREREQUISITE: NS 3061.

NS 3070 Naval Warfare and National Security (4-0).
This is an introductory course specifically designed for students in NPS warfare curricula. It focuses on the role of the U.S. Navy as an instrument of U.S. security policy and on the Soviet Navy as the primary naval threat to U.S.interests. It places the use of both navies in the context of a dynamic naval balance and of a changing international system.

NS 3078 The Politics of Global Economic Relations (4-0).
An integrated analysis on the economic and political factors that together determine national and international economic arrangements. The student first addresses the general principles of public finance as a prerequisite for the analysis of budgets, and policy priorities in specific countries and areas. The remainder of the course is concerned with the changing world economic order, including issues such as trade, aid, multi-national corporations, technology and strategic resources.

NS 3079 Political and Economic Determinants of National Power (4-0).
A comparative analysis of capitalist and planned economics focusing on the United States, Soviet Union, Great Britain, Japan and selected developing countries. Alternative systems are compared with respect to the economic and development goals, theories of economic organization, institutions, and development processes. Emphasis is placed on forecasts of likely changes in economic conditions, and their effect on the political-military situation in each country. PREREQUISITE: NS 3061.

NS 3164 Comparative Ideologies (4-0).
Analysis of the major ideological forces in contemporary world affairs and their effect upon foreign and defense policies, with special emphasis on Marxian political and social thought. Analysis and comparison of the concepts of democracy, socialism, and fascism. Use of primary source material. PREREQUISITE: A course (upper division or graduate) in the History of Western Philosophy, or Political Theory, or consent of Instructor.

NS 3169 Comparative Political Analysis and Research Methods (4-0).
An analytical and comparative study of the form and functioning of the major types of contemporary governments, with emphasis on the policymaking process and research methods.

NS 3172 Public Policy Processes (4-0).
A presentation of the processes by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. prerequisites: MN 3140, MN 3161, MN 3105. Consent of Instructor. *May be given as MN 3172.*

NS 3262 Theory and Practice of International Politics (4-0).
A theoretical systematic analysis of international relations and a study of factors, organizational strategies, and techniques of international politics.

NS 3275 International Law (4-0).
An introduction to the principles of International Law including sovereignty, territory, recognition, the Law of the Sea, and the laws of war. Special emphasis is on the Law of the Sea, its development, practice, and prospects.

NS 3276 The Law of War (4-0).
The course presents and analyzes the law of war as it is to be observed and enforced by the Armed Forces of the United States. Special attention is paid to the 1949 Geneva Conventions, the Navy's *Law of Naval Warfare* and the Army's *Law of Land Warfare.*

NS 3279 Directed Studies in National Security Affairs (Credit open).
Format and content vary. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examination.

NS 3280 Nuclear Weapons and Foreign Policy (4-0).
An interdisciplinary course which covers both the technology and political influences of nuclear weapon systems. The course emphasizes the interaction of nuclear weapon systems with the foreign policies of the major powers and the political blocs from 1945-present.

NS 3300 Problems of Government and Security in the Middle East (4-0).
An introductory course in Middle Eastern society and politics designed to provide the maximum background area knowledge to be utilized in follow-on courses in Middle Eastern politics.

NS 3310 North Africa: Government and Security in the Maghreb (4-0).
This course is designed to extend the student's knowledge of selected North African and Red Sea littoral countries, and to provide some insight into the security problems presented by their domestic politics. In addition, some coverage of central African countries will be included.

NS 3312 Seminar on Middle East Oil (4-0).
An examination of the oil resources of the Middle East for their impact upon the internal, regional, and international policies of region-states. The role of international oil companies, consuming states, and organizations of exporting countries is studied. Differences in oil resources and revenues are examined and related to different developmental and international policies. The past and future use of oil as a political weapon is discussed and evaluated. The use of revenues from oil is examined for its impact on levels of development and the regional military balance.

NS 3313 Political Economy of the Middle East (4-0).
A survey of the major issues of development economics in selected Middle Eastern countries. The basic types of political-ideological systems in the region are examined. A detailed analysis of the economies in each system is made with the ultimate objective of assessing future political-economic developments in the area. PREREQUISITES: NS 3078 and NS 3300.

NS 3314 Problems of Government and Security in Israel (4-0).
Israeli cultural, social, and political patterns: Hebraic traditions, Zionism and the creation of Israel, institutional and sociological frameworks for Israeli politics, elite recruitment, perceptions and strategic orientations, security issues in Israeli domestic and foreign policy. PREREQUISITES: NS 3300 or NS 3331, or their equivalent.

NS 3315 The Middle East: The Military Dimension (4-0).
An examination of the political, sociological, cultural and strategic roles of the military in Middle Eastern history and politics. Among the topics considered are: traditional military patterns, military recruitment, organization, doctrine, and learning experiences.

NS 3316 Problems of Government and Security in the Northern Tier: Turkey, Iran, Afghanistan, Pakistan (4-0).
An examination of internal and external political, economic, and social forces in the major non-Arab Middle Eastern states as reflected in their internal development and international policies. Cooperation and conflict in the behavior of these nations toward each other will be explored in the context of their recent efforts at regional cooperation and regional organization (the Sa'dabad Pact, Cento, and RCD). Examination of their relationships to the major outside powers interested in the area, i.e., the U.S. and the Soviet Union. Their relationships both as individual states and as a sub-region with the Arab states of the Middle East. PREREQUISITES: NS 3300 and NS 3320.

NS 3320 International Relations and Security Problems in the Middle East (4-0).
The course focuses on selected problems affecting American security interests in the Middle East: Strategic waterways, including the Suez Canal, the Turkish Straits, and the Indian Ocean; the politics and problems

of access to the area's oil resources; the development of U.S. and Soviet policies toward area. The foregoing problems will be set in the context of regional international politics.

NS 3330 Military Geography and History of the Middle East (4-0).
An intensive course in Middle Eastern history from the viewpoint of geographical and military factors which have shaped the course of events in the area. The geographic (including oceanographic) environment within which military campaigns have been conducted, which continues to present military problems, is examined. Indigenous and foreign techniques and tactics for dealing with this environment, as well as the historical development of Middle Eastern military organizations are studied.

NS 3331 20th Century Middle Eastern Military and Political History (4-0).
A follow-on course to NS 3300 which continues the study of Middle Eastern history from the 19th through the 20th Century. Emphasis is placed on the political and military factors which shaped strategic events. Special attention is given to the genesis and development of nationalist movements in the area and their impact on Middle Eastern politics. PREREQUISITE: NS 3300.

NS 3350 Area Colloquium in Middle Eastern Studies I (2-0).
A colloquium covering designated topics, open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

NS 3351 Area Colloquium in Middle Eastern Studies II (2-0).
A colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

NS 3400 Domestic Determinants of Soviet National Security Policy (4-0).
A study of Russian and Soviet political inheritance, ideology, religion, political and economic structures, strategic posture, military capabilities, and leadership.

NS 3410 Soviet National Security and Foreign Policy-Making Processes (4-0).
A study of the processes which determine the national security and foreign policies of the Soviet Union. The main focus will be on foreign policy and the dynamics of decision-making in Soviet national security affairs.

NS 3420 Soviet Naval and Maritime Strategy (4-0).
Examination of the roles played by the Soviet Navy, Merchant Marine, Fishing Fleet, and Oceanological establishment in securing the objectives of the Soviet Government. Topics include: geographic factors affecting Soviet ocean strategies; non-naval strategy trends; international and domestic factors affecting post-1953 naval strategy; development of Soviet naval warfare capabilities; doctrinal and functional analysis of post-1953 trends in naval strategy; command structure; personnel training; law of the sea positions; U.S.-Soviet naval interaction.

NS 3430 Soviet Military Strategy (4-0).
Economic, historic and geographic influences on Russian military operations and strategies emphasizing the Soviet era and alternative future Soviet military developments and strategies are examined.

NS 3440 Comparative Communist Political Systems (4-0).
An analysis of structure and policy-making processes of existing communist political systems, of major functions performed by them, and significant factors affecting system development.

NS 3450 Area Colloquium in Soviet Studies I (2-0).
A colloquium covering designated topics, open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

NS 3451 Area Colloquium in Soviet Studies II (2-0).
A colloquium covering designated topics, open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

NS 3600 Geography, History and Cultures of Asia (4-0).
An introduction to Asia. This basic course addresses the peoples of Asia and their cultures, civilizations, social organization, economic, political and military development before the coming of Europeans. This course is a pre-requisite for the advanced courses on Asia.

NS 3601 International Conflicts of Asia to World War II (4-0).
An analysis of the impact of the West on the peoples of Asia, showing the historical roots of many contemporary conflicts of policy.

NS 3602 U.S. Security Interests and Policies in Asia since World War II (4-0).
A study of the national interests of the United States in East Asia, South Asia and adjacent oceans from World War II to the present. The development of hostilities in Korea and Vietnam and their aftermath. Evaluation of relations with the new Japan, the PRC and Taiwan, and the independent nations of Asia, produced by the breakup of traditional empires.

NS 3606 Problems of Government and Security in Southeast Asia (4-0).
Consideration given to such internal problems as the growth of nationalism, the role of overseas Chinese, and numerous other social changes, economic modernization, insurgencies, conflicting ideologies and the various types of government. External problems include the role of each nation state and regional groups in international affairs and the interests and policies of outside powers in dealing with the area.

NS 3607 Problems of Government and Security in Australia, the Neighboring States and Adjacent Oceans (4-0).
The politics, economics and foreign relations of Australia, New Zealand and neighbors to the north and east. The increasing importance of the area's relations with the United States, the Commonwealth, Western Europe, and international organizations.

NS 3611 Problems of Government and Security of Contemporary Japan (4-0).
The place of Japan in the modern world; and examination of Japan's political dynamics, economic evolution, social transformation, the National Self Defense Forces and alternatives for providing for national security.

NS 3612 Problems of Government and Security in China (4-0).
The rise of the Chinese Communist Party and the establishment of the Communist state; its domestic achievements and problems; the special problem of Taiwan; changing foreign policies and the current role of the Peoples Republic of China in world affairs.

NS 3613 Problems of Government and Security of Contemporary Korea (4-0).
Division of the Korean nation into two states; the aftermath of the Korean war; domestic political, economic and social problems of North Korea and South Korea; the prospects for reunification; the military balance and the changing strategic environment; the relations of Pyongyang and Seoul, with their key allies.

NS 3620 Government and Security in South Asia and the Indian Ocean Area (4-0).
Internal problems and foreign relations among the states in the region of South Asia and the Indian Ocean; the strategic interests of the major powers; the importance of the Indian Ocean to the United States, the Soviet Union and their respective allies.

NS 3700 Strategic Geography and the History of Europe (4-0).
The course links the political and military experiences of the European states and political blocs of the 19th and 20th Centuries with the decisive constraints and opportunities of geography. The advanced elements of geography, which serve as the fundamental framework in political and military decisionmaking, as systemically arranged and examined within Europe. Strategic position, area, physiography, population, technology, and economic resources are presented as the basic elements which have influenced the political and military events of the recent past and can help in forecasting the future.

NS 3701 Recent History of Europe and the U.S.S.R. (4-0).
This course continues the narrative and analysis begun in NS 3700 Strategic Geography and History of Europe, bringing the student from the Bolshevik Revolution and the Treaty of Versailles to the present.

NS 3710 International Relations and Security Problems of the Mediterranean (4-0).
This course is designed to provide an introduction to security problems in and around the Mediterranean. It will focus on the stra-

tegic problems of access to, and defense of the Mediterranean littoral: communication routes in and through the Mediterranean; Western and Soviet interests in the Mediterranean; politics and policies of the surrounding states.

NS 3720 Problems of Government and Security in Contemporary Europe (4-0).
Problems of the European political system since World War II. Emphasis on the interrelation of European states (EEC and CMEA), the polarization of Europe between two security systems (NATO and the Warsaw Pact) and relations between the European states and the Third World.

NS 3725 International Relations and Security Problems of the North Atlantic Alliance (4-0).
The origins and evolution of NATO in relation to the perceived threat from the East and the postwar recovery of Europe. Problems of strategy, force posture, alliance cohesion, nuclear policy and the differing interests of NATO states. Current issues facing the alliance and their relation to U.S. foreign and defense policy.

NS 3740 Problems of Government and Security in the Scandinavian-Baltic Region (4-0).
This course analyzes the political, economic, social, and security problems faced by the Scandinavian-Baltic countries. The role they play on the northern flank of NATO will be examined as well as their position vis-a-vis the growing threat of Soviet military and naval power in the Baltic and Norwegian seas.

NS 3750 Area Colloquium in European Studies I (2-0).
A colloquium covering designated topics, open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

NS 3751 Area Colloquium in European Studies II (2-0).
A colloquium covering designated topics, open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

NS 3811 History and Culture of Sub-Saharan Africa (4-0).
An examination of the major historical trends that have shaped African societies. Emphasis will be placed on the interaction between geography, culture, economics and politics. The pre-colonial, and colonial periods in African history will be discussed in detail. This course is intended as a general introduction for the student just beginning the study of Africa.

NS 3813 Problems of Government and Security in Sub-Saharan Africa (4-0).
Emergence of independent African states from a shared colonial heritage, and their common problems in developing viable modern nation-states. Patterns of international cooperation and conflict among African states, including discussions of African socialism, negritude, pan-Africanism, neutralism, and the continuing problem of South Africa's future. Rival policies of outside powers, including the U.S., the Soviet Union, China and the former colonial powers.

NS 3820 Great Powers in Africa (4-0).
A comparative analysis of the great powers and their foreign policies in Africa. This course focuses on USSR and USA, but also deals with the limited Chinese involvement. The effects of great powers and trans-national forces on African states in relation to great powers. Analysis of national liberation movements and their potential competition in Southern Africa in the mid 1980's.

NS 3830 African Political Development Strategies (4-0).
An examination of the political modernization strategies adopted by post-independence governments in Africa. Issues to be discussed will include: the role of political parties in Africa, economic development, the role of the military in Africa, socialism in Africa, and the like. Special emphasis will be placed on Africa's early post-independence problems and their effect on current African strategies.

NS 3850 Area Colloquium in African Studies I (2-0). NS 3851 Area Colloquium in African Studies II (2-0).
Colloquia, open to students completing their language studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. *Graded on Pass/Fail basis only.*

NS 3900 International Organizations and Negotiations (4-0).
The first part of the course traces the evolution of international organizations from the Concert of Europe, through the League of Nations, United Nations, European Economic Community and NATO, to current forms of organization such as multinational corporations and transnational terrorist groups. The emphasis is on the policymaking process in these organizations and their interaction with nation-States and the international system. The second part of the course is an analysis of international negotiations, with emphasis on applying theories of negotiation to such issues as conflict resolution and arms control.

NS 3901 Ocean Policy (4-0).
Examination of policy choices for the United States and other governments concerning political, military, legal, environmental, and economic problems of the sea.

NS 3902 Science, Technology, and Public Policy (4-0).
An inquiry into the role of science and technology in the formulation and conduct of national policy. Interactions between scientific communities, government, and military services.

Graduate Courses

NS 4061 Survey of Strategic Studies (4-0).
An extensive survey of the classical and contemporary literature on strategic thinking; national objectives and strategic alternatives; deterrence, counterforce, arms control, counter insurgency, compellence; components and rules of the international strategic system; arms competitions, nuclear proliferation, terrorism. Student projects on current strategic problems are a major component of the course. PREREQUISITE: NS 3262.

NS 4063 Naval Threat Analysis (4-0).
Introduction to different types of naval threat analyses and to the purposes, problems, and procedures associated therewith. Attention is paid to sources of information available to analysts, and to threat analysis products of U.S. Intelligence activities. Students will engage in a classroom simulation of an operational intelligence activity charged with analyzing a "developing threat." SI access required. *Graded on Pass/Fail basis only.*

NS 4064 Comparative Command, Control, Communications and Ocean Surveillance (3-0).
An examination of the command and organizational structures, control philosophies, communications systems and ocean surveillance systems of the Soviet and U.S. Navies. The course begins with the Soviet approach, which is used as a basis of comparison with the U.S. approach. Possible exploitable features of the command and control structure are considered. The course emphasizes readings in the appropriate literature, research and seminar discussions. PREREQUISITES: NS 3420, TOP SECRET clearance with access to special intelligence information. SE 2003, OS 3002 or equivalent. *May also be taught as SE 4064.*

NS 4077 Strategic Resources and U.S. National Security Policy (4-0).
Analysis of the problems of access to global resources and their utilization: agricultural production; access to critical raw materials; problems and politics of oil; national and international implications of various strategies of self-sufficiency and interdependency. Emphasis is placed on the security problems arising from the geographic distribution of international resources. PREREQUISITES: NS 3061, NS 3262.

NS 4140 Problems of Security Assistance and Arms Transfers (4-0).
An analysis of the patterns, purposes and effects of cross-national security assistance, including arms sales and the transfer of technology. Special topics include: factors dominating the arms transfer policies of the major powers; the role of the military in recipient nations; the role of the military attache; the design, execution and evaluation of security assistance programs. PREREQUISITES: NS 3061 or NS 3262.

NS 4161 American National Security Objectives and Net Assessment (4-0).
Comparative analysis of trends in U.S. and Soviet security policies, military forces, manpower, and capabilities. Special attention is paid to familiarizing students with original source material and major elements in current controversial national security issues. Topics covered include nuclear capabilities and doctrine, BMD and air defense, civil defense, combined arms employment, NATO Warsaw Pact military balance, naval forces, and trends in the U.S. and Soviet ecomies, especially as they affect the allocation of resources to defense.

NS 4207 Special Topics in the Analysis of Intelligence Problems (4-0).
An examination of special intelligence problems and cases with emphasis on problem and project formulation, structure, and management, as well as the interpretation and communication of study results. The last portion of the course will focus on student presentation of thesis research. PREREQUISITES: NS 3062, OS 3002, NS 4063. *Graded on Pass/Fail basis only.*

NS 4273 American Foreign Policy and World Politics (4-0).
An advanced study of the underlying assumptions and objectives of American security and foreign policy. The core of the course is an in-depth analysis of the American national interest in the international context. Students are required to write a major seminar paper on American national interests in a specific country or region.

NS 4279 Advanced Directed Studies in National Security Affairs (Credit open).
Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

NS 4300 Seminar in Security Problems of the Middle East (4-0).
Advanced Middle Eastern politics and the security problems they present to U.S. decision-makers. The central theme of the course is U.S. interests in the Middle East, how these interests are threatened, and what policy alternatives have been proposed to secure them. PREREQUISITE: NS 3300 or NS 3320.

NS 4330 Seminar in Middle Eastern Civilizations (4-0).
Description and analysis of the four major cultural traditions of the Middle East: Arabic, Persian, Judaic, and Turkish. Students read translations of selected classical and contemporary writings from each of these traditions, and secondary materials concerning social and cultural institutions. PREREQUISITES: NS 3300 or NS 3330, or consent of Instructor.

NS 4400 Seminar in Soviet Security Problems (4-0).
Course is designed to provide students with an opportunity to engage in advanced study and research in specialized topics relating to the USSR. PREREQUISITES: Two 3000 level courses on the Soviet area.

NS 4425 Advanced Topics in Soviet Naval Affairs (4-0).
Advanced study and research in Soviet naval and maritime affairs. Topics include: decision-making processes, scenarios, warfare capabilities and support systems, missions; and U.S.-Soviet naval interactions.

NS 4610 Asia and Soviet Union (4-0).
An advanced study of the interests and policies of the Soviet Union in Asia and the adjacent oceans, with special reference to the impact of Soviet expansiveness on the policies of the United States, China, Japan and other Asian States. This course is open both to Soviet and Asian area specialists.

NS 4630 International Security Problems of Asia and the Adjacent Oceans (4-0).
Advanced study of Asian security issues with special emphasis on the balance of forces, regional and external alliances, prospects for conflict, and Asian concepts of security and strategy. Prerequisite is consent of the Instructor.

NS 4679 Advanced Directed Studies in Asian Security Affairs. (Credit open).
Normally involves extensive individual research under direction of instructor and submission of substantial paper of graduate seminar quality and scope. Designed for advanced study in one of the following areas: Japan, Korea, China, South or Southeast Asia.

NS 4700 Seminar in Soviet-European Relations (4-0).
A seminar intended to deepen the student's knowledge of current issues in Soviet and European affairs.

NS 4701 Seminar in Political and Security Problems of Europe (4-0).
A research seminar on political and security issues in contemporary Europe. Students conduct and present original research on a selected issue, or related issues, in specific European countries or subregions. The issue around which the seminar is structured varies from term to term. It is chosen to meet the research interests of each group of students enrolled in the course.

NS 4800 Current Problems in Africa (4-0).
This course will examine the major problems and crises that have confronted African

leaders since 1970. Particular attention will be paid to conflicts in Southern Africa. The OAU's role in conflict management will also be discussed.

NS 4810 American Policy Towards Africa (4-0).
The central theme of the course is U.S. interests in Africa, how these interests are threatened, and what policy alternatives have been proposed to secure them. Advanced African politics and the security problems they present to U.S. decision-makers. PREREQUISITES: NS 3313, NS 3830 or NS 3820.

NS 4900 Seminar in Ocean Policy (4-0).
An advanced survey of the oceanographic, military, political and legal problems of the oceans. Among the topics dealt with are: comparative regional military oceanography, politics and strategy of fleet deployment, and international legal constraints on naval operations.

NS 4901 Seminar in International Negotiations (4-0).
Advanced study and research of the international negotiating process, designed to provide students with an opportunity to analyze specific topics related to negotiating national security.

Discussion of National Security Affairs students in the Asian Seminar room

DEPARTMENT OF OCEANOGRAPHY

R/V ACANIA outfitted for air-sea interaction studies

Christopher Northrup Kennard Mooers, Professor of Oceanography; Chairman (1979)*; B.S., U.S. Naval Academy, 1957; M.S. in Physics, Univ. of Connecticut, 1964; Ph.D. in Physical Oceanography, Oregon State Univ., 1969.

Robert Hathaway Bourke, Associate Professor of Oceanography (1971); B.S., Naval Academy, 1960; M.S., Oregon State Univ., 1969; Ph.D., 1972.

Calvin Ray Dunlap, Lieutenant Commander, U.S. Navy; Assistant Professor of Oceanography (1979); B.S., U.S. Naval Academy, 1962; M.S., Naval Postgraduate School, 1968; M.A., Stanford Univ., 1971.

Roland William Garwood, Jr., Assistant Professor of Oceanography (1976); B.S., Bucknell Univ., 1967; Ph.D., Univ. of Washington, 1976.

Eugene Clinton Haderlie, Distinguished Professor of Oceanography (1965); A.B., Univ. of California at Berkeley, 1943; M.A., 1948; Ph.D., 1950.

Ola Mathias Johannessen, Adjunct Research Professor of Oceanography; Chair in Arctic Marine Sciences (1981); Cand. mag. degree; Univ. of Bergen, 1962; Cand. real. (Ph.D. equiv), 1972.

Glenn Harold Jung, Professor of Oceanography (1958); B.S., Massachusetts Institute of Technology, 1949; M.S., 1952; Ph.D., Texas A&M Univ., 1955.

Dudley Wade Leath, Lieutenant Commander, U.S. Navy; Instructor in Hydrography (1979); B.S., U.S. Naval Academy, 1970; M.S., Scripps Institution of Oceanography, 1974.

Gerald Bryan Mills, Lieutenant Commander, NOAA; Instructor in Hydrography (1980); B.A., Washington State Univ., 1967; M.S., Naval Postgraduate School, 1980.

James Lowell Mueller, Adjunct Research Professor of Oceanography (1980); B.S., U.S. Coast Guard Academy, 1962; Ph.D., Oregon State Univ., 1974.

Robert George Paquette, Professor of Oceanography (1971); B.S., Univ. of Washington, 1936, Ph.D., 1941.

Timothy Peter Stanton, Adjunct Research Instructor in Oceanography (1978); B.S., Univ. of Auckland, New Zealand, 1975; M.Sc., 1978.

Edward Bennett Thornton, Professor of Oceanography (1969); B.A., Williamette Univ., 1962; B.S., Stanford Univ., 1962; M.S., Oregon State Univ., 1965; M.E.C.E., Univ. of Florida, 1966; Ph.D., 1970.

Eugene Dewees Traganza, Associate Professor of Oceanography (1970); B.A., Indiana Univ., 1955; M.S., Texas A&M Univ., 1959; Ph.D., Univ. of Miami, 1966.

Stevens Parrington Tucker, Assistant Professor of Oceanography (1968); B.S., Stanford Univ., 1955; M.S., Oregon State Univ., 1963; Ph.D., 1972.

Joseph John von Schwind, Associate Professor of Oceanography and Geodetic Sciences (1967); B.S., Univ. of Wisconsin, 1952; M.S., Univ. of Utah, 1960; Ph.D., Texas A&M Univ., 1968.

Jacob Bertram Wickham, Associate Professor of Oceanography (1951); B.S., Univ. of California at Berkeley, 1947; M.S., Scripps Institution of Oceanography, 1949.

Andrew John Willmott, Assistant Professor of Oceanography (1981); B.S., (Honors) in Mathematics, Univ. of Bristol, 1975; M.S., Univ. of East Anglia, 1976; Ph.D., 1978.

Emeritus Faculty

Dale Frederick Leipper, Professor Emeritus (1968); B.S., Wittenberg Univ., 1937; M.A., Ohio State Univ., 1939; Ph.D., Scripps Institution of Oceanography, 1950; Hon. D.Sc., Wittenberg Univ., 1968.

Warren Charles Thompson, Professor Emeritus (1953); B.A., Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas A&M Univ., 1953.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

Oceanography is the study of the physical, chemical, geological, and biological systems of the sea. At NPS physical oceanography is emphasized, including its relationships with meteorology and physics, especially in topics of air-sea interaction and underwater acoustics, optics, ice physics, and small scale processes respectively. In all these matters, ocean prediction is the central thrust; that is, the analysis of the ocean's present and future states, and their influence on naval operations and systems. Hydrography (a discipline of mapping, charting and geodesy or MC&G) is the science of the measurement, description, and mapping of the sea floor with special reference to navigation and marine operations. The Department of Oceanography is the center for these studies at NPS. Officers are prepared to make best use of knowledge and understanding of the ocean environment in the course of their duties, and to carry out and evaluate research in oceanography and hydrography, both basic and applied.

The curricula and the research vessel are sponsored by the Oceanographer of the Navy. Research is supported through grants and contracts with various government agencies including the Office of Naval Research.

DEPARTMENT REQUIREMENTS FOR DEGREES IN OCEANOGRAPHY

MASTER OF SCIENCE IN OCEANOGRAPHY
or
MASTER OF SCIENCE IN OCEANOGRAPHY (HYDROGRAPHY)

Entrance to programs leading to these masters degrees requires a baccalaureate degree. Minimal requirements include mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry. Previous experience at sea is considered advantageous.

The masters degree programs require:

a. Completion of thirty-five quarter hours of graduate courses of which fifteen hours must be in the 4000 Oceanography series. The entire sequence of courses for the particular option selected must be approved by the Department of Oceanography.

b. For the Hydrography option, OC 3901, OC 3902, OC 3903, OC 3904, OC 3905, OC 3909, OC 4212, OC 4906, OC 4907, OC 4908 are required.

c. Completion of an acceptable thesis on a topic approved by the Department of Oceanography.

MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

1. Direct entrance to a program leading to the degree Master of Science in Meteorology and Oceanography requires a baccalaureate degree in meteorology and/or oceanography or equivalent. This normally permits the validation of required undergraduate courses such as physics, chemistry, differential equations, linear algebra, vector analysis, and various courses in meteorology and/or oceanography, which are prerequisites to the graduate program. The prerequisites may be taken at the Naval Postgraduate School; however, in that event the program may be lengthened by one or two quarters.

2. The degree of Master of Science in Meteorology and Oceanography requires:

a. Completion of 48 quarter hours of graduate courses in meteorology and oceanography including MR/OC 4413, MR 4322, MR/OC 4323 and 10 quarter hours in the 40000 oceanography series. The degree program must be approved by both the Department of Meteorology and the Department of Oceanography.

b. Completion of an acceptable thesis on a topic approved by either department.

DOCTOR OF PHILOSOPHY

Department of Oceanography admission requirements for the degree of Doctor of Philosophy are:

a. A Master's degree (or the equivalent) in science or engineering or

b. A Bachelor's degree with a high QPR or

c. A successful first graduate year on a Master's program, with clear evidence of research ability.

A student who plans to undertake doctoral work in oceanography must discuss these plans with the Chairman, Department of Oceanography, who is authorized to admit students to doctoral programs. Regular guidelines, as outlined by the Curricular Officer and the Academic Associate, should then be followed.

LABORATORY FACILITIES

The vast computational, data archival, and satellite image processing resources of the School, Naval Environmental Prediction Research Facility, and Fleet Numerical Oceanography Center are available.

The Department has physical, biological, and chemical oceanography laboratories.

The School operates the R/V ACANIA, a 126-foot vessel, for use in oceanographic instruction and research.

DEPARTMENTAL COURSE OFFERINGS

OC 0110, 0111, 0112 Application Seminars (1-0).
Presentation of DOD related research activities, applications to weapons and warfare systems, utilization of oceanography and meteorology in specific billets, presentations by faculty, staff, selected students, visiting authorities. OC 0110 is for orientation; OC 0111 is for beginning students; OC 0112 is for advanced students. PREREQUISITE: Enrollment in an Air-Ocean Science curriculum.

OC 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

OC 0999 Seminar in Oceanography (2-0).
Students in the various oceanography curricula present their theses for discussion. PREREQUISITE: Preparation of a thesis or a research paper concurrently.

Upper Division Courses

OC 2001 Ocean Systems (4-0).
This course is designed to support the Naval Intelligence curriculum by providing an overview of significant oceanographic factors, data networks and their products, sound propagation in the ocean, active and passive sonar and ocean vehicle design practices.

OC 2120 Survey of Oceanography (4-0).
An integrated view of the whole field of oceanography including physical, biological, geological, and chemical aspects. PREREQUISITES: College physics and calculus.

Upper Division or Graduate Courses

OC 3120 Biogeochemical Processes in the Ocean (4-3).
Basic biological, geological, and chemical processes in the ocean. Bioacoustics, deep scattering layers, and bio-deterioration. Geomorphic features of the ocean floor; kinds and distribution of ocean bottom features. Chemical composition of the ocean; molecular level influences on sound attenuation, non-acoustic ASW, and other applications.

OC 3130 Mechanics of Fluids (3-2).
Fundamentals of the mechanics of fluids as a basis for geophysical fluid dynamics: introduction to field concepts, conservation principles, forces and effects, stress and rate of strain, momentum, energy, irrotational flow, introduction to turbulence and boundary-layer flow. Emphasis on problem solving. PREREQUISITE: MA 2121 equivalent or concurrently.

OC 3140 Probability and Statistics for Air-Ocean Science (2-2).
Basic probability and statistics, in the air-ocean science context. Techniques of statistical data analysis. Structure of a probability model, density, distribution function, expectation and variance. Binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and central limit theorem. Transformations of random variables. Histograms and empirical distributions and associated characteristics such as moments and percentiles. Standard tests of hypotheses and confidence intervals for both one and two parameter situations. Regression analysis as related to least squares estimation. TI-59 competence. PREREQUISITE: Calculus.

OC 3150 Air-Ocean Data Networks (3-2).
Analysis methods for atmospheric and oceanic time series. Correlation, spectrum, and empirical orthogonal function analyses. Statistical objective analysis. Optimal design of air-ocean data networks. PREREQUISITES: MA 2121 and a probability and statistics course.

OC 3212 Polar Meteorology/Oceanography (3-1).
Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea Ice;

its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Aspects of geology and geophysics. PREREQUISITES: MR 3222, OC 3220, or consent of Instructor.

OC 3220 Physical Oceanography (3-3).
Physical properties of seawater. Processes influencing the distribution of heat, salt, and density in the ocean. Currents and water masses. Wind-driven and thermohaline components of the oceanic general circulation.

OC 3221 Ocean Circulation Analysis (4-0).
Ekman dynamics and flow properties. Geostrophic dynamics and flow properties. Conservation of potential vorticity. Sverdrup transport. Westward intensification. Use of satellite altimetry in dynamic calculations. PREREQUISITE: OC 3220.

OC 3261 Oceanic Factors in Underwater Sound (4-0).
Examines the oceanic factors which influence sound propagation in the ocean and the effects these factors have in acoustic forecasting. Factors considered include temporal and spatial variations in sound speed profiles, ambient noise, biological effects, reflection characteristics of ocean surface and bottom, signal fluctuations, and forecasting ocean thermal and sound speed structure. This course is designed for the Engineering Acoustics Curriculum. PREREQUISITES: PH 3452 and OC 2120.

OC 3321 Air-Ocean Fluid Dynamics (4-0).
The hydrodynamical equations for a rotating fluid. Forces, kinematics, simple balanced flows, barotropy, baroclinicity, vertical shear, various vertical coordinates. Friction and boundary layers, introduction to scale analysis. Vorticity and divergence equations. PREREQUISITES: MA 2047, MA 2121 (may be concurrent), or equivalent.

OC 3325 Marine Geophysics (3-0).
Theory and methods of marine geophysics surveys, and emphasis on gravity, magnetism, seismic and acoustic wave propagation, heat flow, and radioactivity; geophysical anomalies associated with major seafloor features; acoustic reflectivity of the sea floor; marine geodesy.

OC 3520 Chemical Oceanography (3-3).
Basic chemistry of solutions; chemical compositions of the oceans (dissolved solids, gases, nutrients, etc.); distribution of constituents in the ocean; analytical methods used in chemical oceanography; carbonate, nutrient, and other cycles in the seas; desalination; corrosion, geochemistry. PREREQUISITES: OC 3220 and TI-59 capability.

OC 3610 Wave and Surf Forecasting (2-2).
Prediction and observation of wind-generated ocean waves in deep and shallow water, interpretation of wave characteristics in spectral and statistical terms for operational briefings, and wave-related influences on operations. PREREQUISITES: OC 4211, OC 3150.

OC 3617 Acoustic Forecasting (2-1 for Allies; 2-2 for USN).
Development of synoptic prediction techniques applied to the upper ocean and other environmental factors affecting underwater sound propagation. Acoustical models and their oceanographic input; the tactical and strategic utilization of the model output. Laboratory exercises illustrate principles developed during lectures. USN officer's course expanded to include classified subject matter. PREREQUISITE: OC 4260 or OC 4265.

OC 3621 Regional Military Oceanography (1-2).
Application of the full breadth of the oceanography program, including physical phenomena, geology, biology, chemistry, acoustics and air-sea interaction in order to objectively analyze the significance of the total environment on various aspects of naval warfare for specific oceanic areas of operation. Data sources and operational products are described and utilized. PREREQUISITES: OC 3221, 3120, and 3617.

OC 3625 Ocean Prediction for Underwater Sound Propagation (2-1).
Development of synoptic prediction techniques applied to environmental factors affecting underwater sound propagation. Present acoustic forecasting models are studied in light of adequacy of environmental input data, realism, and computational approximations. This course is designed for the ASW program and is accelerated to six weeks. PREREQUISITE: OC 4265.

OC 3660 Satellite Oceanography (2-2).
Principles of satellite sensors and systems; passive and active microwave sensors; image processing; application of satellite remote sensing data in oceanography. PREREQUISITE: OC 3221.

OC 3801 Ocean Operations (3-0).
Brief surveys of ocean engineering problems of national, Navy and oceanographic interest such as search, recovery and salvage techniques; towing; deep submersibles; unattended moorings; diving and underwater work; corrosion; deep-sea mining and ocean energy sources.

OC 3901 Mapping, Charting, and Geodesy (4-2).
Principles and fundamentals of geodesy, photogrammetry, and cartography. The application of these disciplines to mapping and charting with emphasis on the propagation of random errors inherent in each phase: data acquisition, data reduction, generalization, and protrayal.

OC 3902 Hydrographic and Geodetic Survey (3-3).
Principles and fundamentals of hydrographic surveying, and of support methods from the field of geodetic surveying. Introduction to survey procedures, both at sea and on land including use of surveying instruments. PREREQUISITE: OC 3901.

OC 3903 Electronic Surveying and Navigation (4-0).
Introduction to the theory and practice of electronic surveying and navigation including principles of electronics, electronic surveying systems and basic components, geometry of electronic surveying, ray path curvature, propagation velocity, and velocity applications to surveying. PREREQUISITE: OC 3902.

OC 3904 Hydrographic Measurements (3-2).
Measurements required in hydrographic surveying and necessary corrections. Sources of error. Hydrographic data interpretation, reduction, presentation and quality evaluation. Critical analysis of specific hydrographic survey techniques and methods. PREREQUISITES: OC 3902; concurrent with OC 3909.

OC 3905 Hydrographic Operations (3-2).
Hydrographic survey project planning and management. Selection of appropriate methods and equipment including a survey of contemporary hydrographic measurement systems. PREREQUISITES: OC 3904 and OC 3909.

OC 3909 Hydrographic Cruise (0-4).
Field activities in hydrographic survey support, data acquisition and reduction, and data presentation. PREREQUISITES: OC 3902; concurrent with OC 3904.

Graduate Courses

OC 4211 Dynamical Oceanography (4-0)
Linear theory of surface and internal waves; theory of finite amplitude waves; windwave spectra. Inertial-internal, Rossby, and Kelvin waves. PREREQUISITES: OC/MR 3150, MA 3132, and OC/MR 3321.

OC 4212 Tides (3-0).
Development of the theory of tides including the tide-producing forces, equilibrium tides, and the dynamic theory of tides; harmonic analysis and prediction of tides; tidal datum planes and their relationship with geodetic datum planes, short-term and secular changes in sea level. PREREQUISITE: OC 4211.

OC 4213 Nearshore and Wave Processes (3-2).
Shoal-water wave processes, breakers and surf; nearshore water circulation; beach characteristics; littoral drift; coastal hydraulics, storm surge. PREREQUISITE: OC 4211.

OC 4220 Shallow Water Oceanography (3-2).
Circulation and exchange processes of continental shelf and slope regions, shallow seas, and straits. Dynamics and models of circulations driven by wind, thermohaline, tidal, boundary, current, and ocean eddy forces. PREREQUISITES: OC 3221, OC 4211, OC/MR 3321, and OC/MR 4413.

OC 4260 Ocean Influences in Underwater Acoustics (4-0).
An unclassified version of OC 4265.

OC 4265 Ocean Influences in Underwater Acoustics (4-0).
Examines the environmental factors which influence sound propagation in the ocean. Factors considered include temporal and spatial variations in sound speed profiles, bient noise, absorption, and reflection characteristics of the sea surface and ocean bottem, signal fluctuations, and transmission loss models. This course is designed for the ASW and Air-Ocean Science curricula. PREREQUISITES: OC 2120 or OC 3221, PH 3431 or PH 2471; U.S. Citizenship and SECRET clearance.

OC 4323 Numerical Air and Ocean Modeling (4-3).
Numerical models of atmospheric and oceanic phenomena. Finite difference techniques for solving elliptic and hyperbolic equations, linear and nonlinear computational instability. Barotropic and primitive equation prediction models. Sigma coordinate. Objective analysis and initialization. Moisture and heating as time permits. PREREQUISITES: MR 4322 and MA 3232.

OC 4330 Synoptic Oceanography (3-2).
Principles and practices of synoptic analyses of oceanic cyclonic and anticyclonic eddies, oceanic density and density-compensated fronts, and boundary currents and their meanders. Use of in-situ and remotely sensed real time reports as well as climatologies and essential dynamics. PREREQUISITES: OC 3221 and OC/MR 3150.

OC 4331 Advanced Synoptic Oceanography (4-0).
Analyze and interpret synoptic information on small scale processes including finestructure. Same for mesoscale, synoptic scale, and large scale processes on a regional basis. PREREQUISITE: OC 4330.

OC 4413 Air/Sea Interaction (4-0).
Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface and Ekman layers, and bulk formulae for estimating air-sea fluxes. The oceanic planetary boundary layer including the dynamics of the well-mixed surface layer. Recent papers on large-scale air-sea interaction. PREREQUISITE: OC/MR 3321, OC 4211, MR 4322 or consent of Instructor.

OC 4414 Advanced Air/Sea Interaction (3-0).
Advanced topics in the dynamics of the atmospheric and oceanic planetary boundary layers. PREREQUISITE: OC/MR 4413 or consent of Instructor.

OC 4425 Advanced Biological Oceanography as Applied to Naval Operations (2-3).
A study at the advanced level of the biological phenomena of the sea that have influences on naval operations. Topics include the biodeterioration of engineering materials in the sea, boring and fouling organisms, bioacoustics, bioluminescence, sound scattering by planktonic organisms, toxic and dangerous marine organisms, influence of naval operations on marine ecological systems, and methods of ecological damage assessment. Includes lectures, laboratory work, field work and cruises. PREREQUISITE: OC 3120.

OC 4800 Special Topics in Oceanography (1-0 to 4-0).
Independent study of advanced topics in oceanography not regularly offered. PREREQUISITE: Consent of the Department Chairman and Instructor.

OC 4906 Geometric and Astronomic Geodesy (4-0).
Properties of the ellipsoid, geometric aspects of geodesy including triangulation, trilateration, traverse, and leveling techniques and instrumentation; adjustment by least squares, astronomic determination of latitude, longitude, and azimuth; time and astronomic instrumentation. PREREQUISITES: OC 3325 or OC 3130 and OC 3902.

OC 4907 Gravimetric and Satellite Geodesy (4-0).
Potential theory as applied to the gravity field of the earth; application of Stokes' Formula, integral, and function; deflection of the vertical; gravimetric reduction; geometric and dynamic applications of satellites, orbital geometry and satellite orbit dynamics. PREREQUISITE: OC 4906.

OC 4908 Photogrammetry and Remote Sensing (3-2).
Application of photogrammetric instruments and techniques to planimetric, topographic, and hydrographic data compliation. Use of analog, semi-analytical, and analytical photogrammetry in geodetic control extension. Planning and execution of aerial photography. Principles and fundamentals of remote sensing. Application of remote sensing imagery to mapping and charting. PREREQUISITE: OC 3902.

DEPARTMENT OF OPERATIONS RESEARCH

Network optimization using microcomputer

Kneale Thomas Marshall, Professor of Operations Research; Chairman (1968)*; B.Sc. (Eng.), Imperial College, London, 1958; M.S., Univ. of California at Berkeley, 1964; Ph.D., 1966.

Alvin Francis Andrus, Associate Professor of Operations Research and Statistics (1963); B.A., Univ. of Florida, 1957; M.A., 1958.

Donald Roy Barr, Professor of Operations Research and Statistics (1966); B.A., Whittier College, 1960; M.S., Colorado State Univ., 1962; Ph.D., 1965.

Gerald Gerard Brown, Professor of Operations Research (1973); B.A., California State Univ. at Fullerton, 1968; M.B.A., 1969; Ph.D., Univ. of California at Los Angeles, 1974.

William Eric Coons, Lieutenant Commander, U.S. Navy; Instructor Operations Research (1980); B.S., Purdue Univ., 1970; M.S., Naval Postgraduate School, 1977.

Jeffrey Lee Ellis, Major, U.S. Army, Instructor in Operations Research (1980); B.S., Northwestern State College of Louisiana, 1967; M.S., Naval Postgraduate School, 1974.

James Daniel Esary, Professor of Operations Research and Statistics (1970); A.B., Whitman College, 1948; M.A., Univ. of California at Berkeley, 1951; Ph.D., 1957.

Robert Neagle Forrest, Professor of Operations Research (1964); B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

Donald Paul Gaver, Jr., Professor of Operations Research and Statistics (1971); S.B., Massachusetts Institute of Technology, 1950; S.M., 1951; Ph.D., Princeton Univ., 1956.

James Kern Hartman, Associate Professor of Operations Research (1970); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

Gilbert Thoreau Howard, Associate Professor of Operations Research (1967); B.S., Northwestern Univ., 1963; Ph.D., Johns Hopkins Univ., 1967.

Wayne Philo Hughes, Jr., Captain, U.S. Navy; Professor, Chair of Applied Systems Analysis (1979); B.S., U.S. Naval Academy, 1952; M.S., Naval Postgraduate School, 1964.

Patricia Anne Jacobs, Associate Professor of Operations Research (1978); B.S., Northwestern Univ., 1969; M.S., 1971; Ph.D., 1973.

Harold Joseph Larson, Professor of Operations Research and Statistics (1962); B.S., Iowa State Univ., 1956; M.S., 1957; Ph.D., 1960.

Peter Adrian Walter Lewis, Professor of Operations Research and Statistics (1971); B.A., Columbia College, 1954; B.S., Columbia Engineering School, 1955; M.S., 1957; Ph.D., Univ. of London, 1964.

Glenn Frank Lindsay, Associate Professor of Operations Research (1965); B.Sc., Oregon State Univ., 1960; M.Sc., Ohio State Univ., 1962; Ph.D., 1966.

Alan Wayne McMasters, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

Paul Robert Milch, Associate Professor of Operations Research and Statistics (1963); B.S., Brown Univ., 1958; Ph.D., Stanford Univ., 1966.

William Francis Moroney, Commander, U.S. Navy; Assistant Professor of Man-Machine Systems (1978); B.A., Cathedral College, 1964; M.A., St. John's Univ., 1967; Ph.D., 1968.

Douglas Elmer Neil, Assistant Professor of Operations Research (1972); B.A., Univ. of Southern California, 1965; M.S., Univ. of Pacific, 1967; Ph.D., North Carolina State Univ., 1971.

Samuel Howard Parry, Associate Professor of Operations Research (1973); B.S., Georgia Institute of Technology, 1963; M.S., Northwestern Univ., 1964; Ph.D., Ohio State Univ., 1971.

Gary Kent Poock, Professor of Operations Research and Man-Machine Systems (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

Robert Richard Read, Professor of Operations Research, Probability and Statistics (1961); B.S., Ohio State Univ., 1951; Ph.D., Univ. of California at Berkeley, 1957.

Francis Russell Richards, Associate Professor of Operations Research (1970); B.S., Louisana Polytechnic Institute, 1965; M.S., Clemson Univ., 1967; Ph.D., 1971.

Ellen Franz Roland, Lieutenant, U.S. Navy; Instructor in Operations Research (1978); B.S., Univ. of Wisconsin, 1972; M.S., Naval Postgraduate School, 1977.

Bruno Otto Shubert, Associate Professor of Operations Research, Probability, and Statistics (1970); M.S., Czech. Technical Univ. at Prague, 1960; Ph.D., Charles Univ. at Prague, 1964; Ph.D., Stanford Univ., 1968.

Rex Hawkins Shudde, Associate Professor of Operations Research (1962); B.A. and B.S., Univ. of California at Los Angeles, 1952; Ph.D., Univ. of California at Berkeley, 1956.

Michael Graham Sovereign, Professor of Operations Research (1970); B.S., Univ. of Illinois, 1959; M.S., Purdue Univ., 1960; Ph.D., 1965. *Currently on leave of absence to OASD (Comptroller).*

Charles Floyd Taylor, Jr., Lieutenant Commander, U.S. Navy; Instructor in Operations Research (1978); B.S., Stanford Univ., 1968; M.S., Naval Postgraduate School, 1975.

James Grover Taylor, Professor of Operations Research (1968); B.S., Stanford Univ., 1961; M.S., 1962; Ph.D., 1966.

Joseph Bryce Tysver, Associate Professor of Operations Research and Statistics (1966); B.A., Washington State Univ., 1942; M.A., 1948; Ph.D., Univ. of Michigan, 1957.

Alan Robert Washburn, Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

Peter William Zehna, Professor of Operations Research and Statistics (1961); B.A., Colorado State College, 1950; M.A., 1951; M.A., Univ. of Kansas, 1956, Ph.D., Stanford Univ., 1959.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be arranged in consultation with the Chairman, Department of Operations Research.

MASTER OF SCIENCE IN APPLIED SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in operations research at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Department of Operations Research. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

MASTER OF SCIENCE IN OPERATIONS RESEARCH

1. A candidate shall previously have satisfied the requirements for the degree of Bachelor of Science in Operations Research or the equivalent.

2. Completion of a minimum of 48 quarter hours of graduate level courses, including at most 8 quarter hours for a thesis.
    a. At least 18 quarter hours of 4000 level operations research/systems analysis courses.
    b. An elective sequence approved by the Department of Operations Research.

3. Submission of an acceptable thesis on a subject previously approved by the Department of Operations Research. This credit shall not count toward the requirement stated in 2a.

DOCTOR OF PHILOSOPHY

The department offers the Ph.D. degree in Operations Research with specializations in the theory and applications of stochastic processes, mathematical optimization, decision sciences, and human factors. The program begins with advanced coursework guided by the student's doctoral committee and leading to the qualifying examination. The primary emphasis then shifts to the student's research program culminating in the Ph.D. dissertation.

Students wishing to enter directly into the doctoral program should write to the department chairman. Detailed admission procedures may vary depending on the individual's location and position. However, in all cases the student must fulfill the schoolwide requirements contained in the general school requirements for the Doctor's degree.

A doctoral student in Operations Research pursues a course of in-depth study with emphasis on the advanced theory of OR and its application to operational problems. The primary emphasis is on independent research leading to the doctoral dissertation.

DEPARTMENTAL COURSE OFFERINGS

OPERATIONS ANALYSIS

OA 0001 Seminar for Operations Analysis Students (0-2).
Guest lecturers. Review of experience tours. Thesis and research presentations.

OA 0810 Thesis Research for Operations Analysis Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

OA 2000 Introduction to Operations Research (2-0).
A first course in Operations Research for students in the OA curriculum. Early origins of Operations Research and development through World War II to current practice. Introduction to fundamental concepts of the OR approach including the role of analytic models, decision variables, and measures of effectiveness. Examples of OR techniques. *Graded on Pass/Fail basis only.*

OA 2601 Introduction to Tactical Analysis (4-0).
Introduces OA students to the concepts, tools, and methods of tactical analysis. The course emphasizes quantitative ways to (1) determine, and (2) improve combat readiness and weapons systems performance, singly and in combination. PREREQUISITES: MA 1116, OA 3101, OA 2000.

OA 2910 Selected Topics in Operations Analysis (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in operations research.

Upper Division or Graduate Courses

OA 3000 Computational Methods for Operations Research (3-2).
Application programming for OR, Markov models, random sample generation, statistical data reduction; introduction to interactive modeling, comparing interactive and batch methodologies, interactive data analysis. PREREQUISITE: CS 2600. *Graded on Pass/Fail basis only.*

OA 3101 Probability (4-1).
Probability axioms and event probability. Random variables and their probability distributions. Moment generating functions, moments and other distribution characteristics, distribution families. Functions of a random variable, including the probability integral transformation. Chebychev inequality, law of large numbers. PREREQUISITE: MA 1115 or equivalent.

OA 3102 Probability and Statistics (4-1).
Jointly distributed random variables, independence and conditional distributions, covariance and correlation. Functions of several random variables, sampling distributions, limiting distributions, the central limit theorem, approximations. Order statistics, the t and F distributions, the bivariate normal distribution. Point estimation, properties of estimators, interval estimation. PREREQUISITES: OA 3101 and MA 2110 or equivalents.

OA 3103 Statistics (4-1).
Confidence intervals, Bayesian intervals, hypothesis testing, significance testing. Regression, analysis of variance, nonparametic inference. Applications to reliability, test and evaluation, and operations research problems. PREREQUISITE: OA 3102 or equivalent.

OA 3104 Data Analysis (3-1).
Techniques of analyzing real data with emphasis on discovery of relationships among factors. The exploratory nature of data analysis is featured through a variety of plotting methods and interactive work on the computer terminals. Includes model building, and the discovery and overcoming of shortcomings in data collected in actual situations. PREREQUISITES: OA 3103, OA 3000, or equivalents.

OA 3201 Linear Programming (4-0).
Theory of optimization of linear functions subject to linear constraints. The simplex algorithm, duality, dual simplex algorithm, sensitivity analyses, parametric linear programming, transportation algorithm and matrix payoff games. Applications to resource allocation, manpower planning, transportation and communications network models, ship scheduling, and elementary strategic games. Introduction to machine computing and MPS. PREREQUISITE: MA 2042.

OA 3301 Stochastic Models I (4-0).
The homogeneous and inhomogeneous Poisson process, filtered and compound Poisson process. Stationary Markov chains and their applications in modelling random phenomena. PREREQUISITE: OA 3102.

OA 3302 System Simulation (4-0).
Discrete event digital simulation methodology. Monte Carolo techniques, use of FORTRAN and other available simulation languages. Variance reduction techniques, design of simulation experiments and analysis of results. PREREQUISITES: CS 2600 or equivalent; OA 3103 or equivalent.

OA 3401-3402 Human Factors in Systems Design I-II (4-0 and 3-0).
The human element in man-machine systems. Selected topics in human engineering and psychophysics with emphasis on their relation to military systems. Man-machine interface and man's motor and sensory capacities. PREREQUISITES: PS 3103, OA 3201.

OA 3501 Inventory I (4-0).
A study of deterministic and approximate stochastic inventory models. Deterministic economic lot size models with infinite production rate, constraints, quantity discounts. An approximate lot size-reorder point model with stochastic demand. An approximate stochastic periodic review model. Single period stochastic models. Applications to Navy supply systems. PREREQUISITE: OA 3102 or equivalent.

OA 3601 Combat Models and Games (4-1).
This course provides an introduction to four specific techniques that find common use in modelling combat. These techniques are Kalman Filtering, Lanchester Systems, Coverage Problems, and Game Theory. PREREQUISITE: OA 3301.

OA 3602 Search Theory and Detection (4-0).
Search and detection as stochastic processes. Characterization of detection devices, use and interpretation of sweep widths, lateral range curves, true range curves. Measures of effectiveness of search-detection systems. Allocation of search effort, sequential search. Introduction to the statistical theory of signal detection. Models of surveillance fields, barriers, tracking, and trailing.

OA 3655 Introduction to Army Operations Research (4-0).
This course develops the role of operations research in Army decision-making. Problems of operations analysis, resource optimization, and program evaluation in Army planning are addressed. Measurement of the effectiveness of Army systems, force structure and cost estimation, COEAs and role of these tools in the fiscal and life cycle decision processes are included. PREREQUISITES: AS 3609, OA 3201.

OA 3900 Workshop in Operations Research/Systems Analysis (2-0 to 5-0).
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

OA 3910 Selected Topics in Operations Research/Systems Analysis (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repreated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research. Consent of Instructor.

Graduate Courses

OA 4101 Design of experiments (3-1).
Theory and applications of the general linear hypothesis model. Analysis of variance and analysis of covariance. Planning experiments, traditional and hybrid experimental designs. Use of standard computer package for analysis of experimentation data. PREREQUISITE: OA 3103 or equivalent.

OA 4102 Regression Models (4-0).
Construction, analysis and testing of regression models. An in-depth study of regression and its application in operations research, economics and the social sciences. PREREQUISITES: OA 3102, OA 3103, OA 3104.

OA 4103 Advanced Probability (3-0).
Probability spaces, random variables as measurable functions, expectation using the Lebesque Stieltjes integral and abstract integration. Modes of convergence, characteristic functions, the continuity theorem, central limit theorems, the zero-one law. Conditional expectation. PREREQUISITE: MA 3605 or departmental approval.

OA 4104 Advanced Statistics (3-0).
Foundations of statistics from a decision-theoretic viewpoint. Robust estimation techniques, biased estimation, Fisher's and Kullback information, asymptotic methods. Sufficiency, completeness, the Cramer-Rao inequality. Sequential tests, empirical Bayes tests. Statistical computation methods. PREREQUISITE: OA 3103 and consent of Instructor.

OA 4190 Selected Topics in Probability and Statistics (2-0 to 5-0).
Topics will be selected by instructor to fit the needs and background of the students. The topics may include advanced probability, sampling inspection, quality assurance, non-parametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: Consent of Instructor. *Graded on Pass/Fail basis only.*

OA 4201 Nonlinear and Dynamic Programming (4-0).
Introduction to modern optimization techniques and multistage decision processes. Kuhn-Tucker necessary and sufficient conditions for optimality, quadratic and separable programming, basic gradient search algorithms, penalty function methods dynamic programming. Applications to weapons assignment, force structuring, parameter estimation for nonlinear or constrained regression, personnel assignment and resource allocation. PREREQUISITE: OA 3201.

OA 4202 Networks Flows and Graphs (4-0).
Survey of solution techniques for problems which can be related to problems involving flows in networks. Elements of graph theory, max-flow mincut theorem, shortest route problems, minimal cost flows, out-of-kilter algorithm, CPM, PERT/Cost, and PERT/Time. PREREQUISITE: OA 3201.

OA 4203 Mathematical Programming (4-0).
Advanced topics in linear programming. Large scale systems, the decomposition principle, additional algorithms, bounded variable techniques, linear fractional programming, probabilistic programming, formulation and solution procedures for problems in integer variables. Applications to capital budgeting, large scale distribution systems, weapon systems allocations and others. PREREQUISITE: OA 3201.

OA 4204 Games of Strategy (4-0).
Mathematical models of conflict situations, emphasizing the theory of decision making against a completely opposed enemy. Applications to ASW, system acquisition, and other solutions to games that are partly cooperative. PREREQUISITE: A course in calculus and in probability.

OA 4205 Nonlinear Programming (4-0).
Continuation of OA 4201. Advanced topics in nonlinear programming including duality theory, further consideration of necessary and sufficient conditions for optimality, additional computational methods and examination of recent literature in nonlinear programming. PREREQUISITE: OA 4201.

OA 4206 Dynamic Programming (4-0).
A continuation of OA 4201. Basic theory of dynamic programming with numerous optimization and resource allocation applications in the areas of reliability design, target selection, inventory theory, project selection and others. D.P. in Markov chains. PREREQUISITE: OA 4201.

OA 4207 Optimization of Time-Sequential Processes (4-0).
Study of time-sequential decision processes. Modeling and optimization of dynamic systems with one or more decision makers. Applications of modern optimal control theory and differential games to problems of military operations research. Typical areas of application are time-sequential combat games (air-war allocation strategies, fire-support allocation strategies), inventory systems, searching for targets, strategic missile allocations, pursuit and evasion, engagement of targets of opportunity. PREREQUISITE: OA 4201 or consent of Instructor.

OA 4301 Stochastic Models II (3-2).
Course objectives are to teach methods of stochastic modeling beyond those taught in OA 3301 and to give students an opportunity to apply these tools to real world problems. Suitably selected projects that entail data collection and analysis are undertaken, with emphasis on problem formulation, choice of appropriate assumptions and attainment of practical results. The theory part of the course usually focuses on renewal processes illustrated by several military and industrial applications.

OA 4302 Reliability and Weapons System Effectiveness Measurement (4-0).
Component and system reliability functions, and other descriptors for the reliability of system effectiveness. Relationships between system and component reliability. Point and interval estimates of reliability parameters under various life testing plans. Illustrations of current methods of reliability assessment from appropriate MIL-STD's and manuals. PREREQUISITE: OA 4301 (may be taken concurrently) or equivalent.

OA 4303 Sample Inspection and Quality Assurance (4-0).
Attribute and variables sampling plans. MIL-STD sampling plans with modifications. Multi-level continuous sampling plans and sequential sampling plans. Structure of quality assurance programs and analysis of selected quality assurance problems. PREREQUISITE: OA 3103 or consent of Instructor.

OA 4304 Decision Theory (3-0).
Basic concepts, Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluations trials. PREREQUISITE: OA 3103.

OA 4305 Stochastic Models III (4-0).
Lecture topics include, non-stationary behavior of Markov processes, point process models, regenerative processes, Markovian queueing network models, and non-Markovian systems. Applications to include reliability, computer system modelling, combat modelling, and manpower systems. Students are given exercises entailing data analysis, formulation of probability models, and application of models to answer specific questions concerning particular phenomenon. PREREQUISITES: OA 3104, OA 3301, OA 4301.

OA 4306-4307 Stochastic Processes I-II (4-0).
The Kolmogorov theorem; analytic properties of sample functions; continuity and differentiability in quadratic mean; stochastic integrals, stationary processes. Stationary and non-stationary problems; Martingale, limit theorems and the invariance principle. PREREQUISITE: OA 4103.

OA 4308 Time Series Analysis (4-0).
Second order stationary processes. Harmonic analysis of correlation functions. Filters and spectral window. Ergodic properties. Problems of inference in time series analysis. Introduction to the analysis of multivariate processes. PREREQUISITE: Consent of Instructor.

OA 4401 Human Performance Evaluation (4-0).
Experimental considerations, strategy, and techniques in evaluation of human performance characteristics and capabilities. Detailed examination of special methods to include multivariate designs, psychophysical methods, and psychophysiological methods. Review of important variable affecting human performance and criteria, measures of effectiveness, and figures of merit as indicants of performance quality. PREREQUISITE: OA 3401.

OA 4402 Skilled Operator Performance (3-2).
First part of the course is devoted to an examination of the theoretical foundations of skilled performance. The second half of the course is devoted to the study of the acquisition, development and prediction of skilled operator performance in the operational setting. PREREQUISITE: OA 3401

OA 4403 Evaluation of Human Factors Data (3-2).
The course is primarily concerned with collection, evaluation, and analyses of data obtained from human subjects. Problem solving and extraction of results from actual human factors data is emphasized. Orientation of the course is toward applied solutions. PREREQUISITES: OA 3102, OA 3401 or equivalent.

OA 4404 Operations Research in Man-Machine Systems (4-0).
Application of operations research techniques to man-machine design and evaluation problems. Specific methodologies include mathematical programming, stochastic processes, decision theory, and other related areas. Quantitative methods for performance will be treated using such concepts as reliability, information theory, and signal detection theory. A portion of the course will be devoted to summarizing approaches to real world problems incorporating current methods from the literature. PREREQUISITES: OA 3401, OA 3201, OA 3301, and OA 4301 (may be taken concurrently).

OA 4501 Seminar in Supply Systems (4-0).
A survey of the supply system of the U.S. Navy. Topics include the inventory models at all levels for consumables and repairables, budget formulation and execution, provisioning and allowance lists, planned program requirements, transaction item reporting, and current topics of research such as stock migration and material distribution studies. PREREQUISITE: OA 3501.

OA 4502 Inventory II (4-0).
A study of stochastic inventory models. Single period models with time dependent costs, constrained multiple item single period models, deterministic and stochastic dynamic inventory models, deterministic and stochastic dynamic inventory models, the (r,R) periodic review model, the Q=1 continuous review model. PREREQUISITES: OA 3301, OA 3501.

OA 4601 Advanced Topics in War Gaming and Simulation (3-2).
A greater-depth coverage of material introduced in OA 3302 and OA 3601. Advanced techniques of model development and simulation experimentation. Discussion of current research. Actual topics selected will de pend on interests of students and instructor. This course is particularly appropriate for those doing thesis in this area. PREREQUISITE: OA 3601 and departmental approval.

OA 4602 Campaign Analysis (4-0).
The development, use, and state of the art of Naval campaign analysis. Emphasis is placed on formulating the analysis, measures of effectiveness, handling assumptions, modeling hierarchies, and parametric tests. Specific ASW and AAW campaign models are examined, "capabilities" and "requirements" analyses are differentiated. The students will study and discuss major portions of actual analyses, such as SEAWAR-85, SEAPLAN 2000, TACNUC WAR AT SEA, SEAMIX III, SEA BASED AIR PLATFORM STUDY, and the MAJOR FLEET ESCORT STUDY. PREREQUISITES: OA 3601 and SECRET NOFORN clearance.

OA 4603 Test and Evaluation (3-2).
This course relates the theory and techniques of operations research to the problems associated with test and evaluation. Specific examples of exercise design, reconstruction, and analysis are examined. PREREQUISITES: OA 3104, OA 4604 or OA 4654.

OA 4604 War Gaming Analysis (4-0).
Analysis of problems in the design, construction and application of manual, computer and interactive gaming. Emphasis is on gaming as a means of evaluating Naval warfare tactics. The Warfare Environmental Simulator (WES) will be used. PREREQUISITES: OA 3302, OA 3601, and OA 3602. SECRET NOFORN clearance.

OA 4605 Operations Research Problems in Naval Warfare (3-0).
Analyses of fleet exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Relationship of air defense to strike capability and ASW. Current radar, sonar, communications, and ECM problems. PREREQUISITE: OA 4604.

OA 4606 Applications of Search, Detection and Localization Models to ASW (3-0).
Applications of search, detection and localization models to search planning, target localization procedures, and ASW sensor evaluation. Both acoustic and nonacoustic sensors are considered. PREREQUISITES: OS 3601 or OA 4604, U.S. Citizenship and SECRET clearance.

OA 4607 Tactical Design and Analysis (4-0).
Use of hand-held programmable calculators (HPCs) and their application to tactical problems in the operational environment. Characteristics of currently available HPCs will be discussed and compared with special emphasis on the use of their more sophisticated features. Methods for implementing environmental, search, localization, and tracking algorithms on the HPC. Individual and/or group projects allow the student to apply the concepts presented in class to problems in his area of expertise. PREREQUISITES: OA 4604, OS 3601 or consent of Instructor and SECRET NOFORN clearance. *Graded on Pass/Fail basis only.*

OA 4654 Land Combat Models I (4-0).
Introduction to modeling air/ground combat operations, with emphasis on detailed approaches for modeling small-scale combat. Students develop skill in basic modeling. Topics include: different types of combat models, verification of models versus modeling. Includes modeling of target-acquisition, fire-assessment (kill probabilities and kill rates), terrain-effects, tactical-decision making and integration of these submodels. The student is introduced to Lanchester-type models of warfare. PREREQUISITES: OA 3301, AS 3611, or equivalent.

OA 4655 Land Combat Models II (4-0).
Modeling of large-scale air/ground combat operations. Participation in a group effort of building and exercising a simple model of large-scale combat. Topics include: historical developments for such models, conceptual foundations of large-scale air/ground combat models, attrition modeling, movement modeling, and C3I process models. Focus is on aggregated-force casualty-assessment models. Topics in Lanchester-type models such as estimation of attrition-rate coefficients and operational enrichments of such models. Computer applications to combat at both a detailed level as well as an aggregated level is discussed. PREREQUISITE: OA 4654.

OA 4656 Land Combat Analysis (4-0).
A capstone course to the sequence of land combat courses. It consists of a mixture of problem definition, review of existing studies, and performance of small study efforts to solve current land-combat problems. PREREQUISITE: OA 4655.

OA 4701 Econometrics (4-0).
Construction and testing of econometric models, analysis of economic time series, and the use of multivariate statistical analysis in the study of economic behavior. PREREQUISITES: OA 4102, AS 3610.

OA 4702 Cost Estimation (4-0).
Advanced study in the methods and practice of systems analysis with emphasis on cost analysis; cost models and methods for total program structures and single projects; relationship of effectiveness models and measures to cost analyses; public capital budgeting of interrelated projects; detailed examples from current federal practices. PREREQUISITE: AS 3611 or equivalent.

OA 4703 Defense Expenditure and Policy Analysis (4-0).
A presentation of the major components of defense budgeting and policy formulation from the standpoint of the three major institutions involved, the agency, executive and congress. The use of quantitative models of institutional behavior is emphasized when examining both individual institutions and the interaction between them. PREREQUISITE: AS 3611.

OA 4910 Selected Topics in Operations Analysis (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research and departmental approval.

OA 4930 Readings in Operations Re-Analysis (2-0 to 5-0).
This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

SERVICE COURSES

OS 0810 Thesis Research for C3 Students (0-0).
Every student conducting thesis research will enroll in this course.

Upper Division Courses

OS 2000 Elements of Operations Research/Systems Analysis (4-0).
An introductory course. Topics covered include nature, origin, and contemporary status of operations analysis; problem formulation. PREREQUISITE: PS 2501 or equivalent.

OS 2101 Analysis of Experimental Data (4-0).
Introduction to statistical analysis of measurements and experimental data. Frequency distributions, graphical representations. Populations and sampling. Principle of least squares, estimation of mean and standard deviation. Curve fitting and regression, propagation of errors. Confidence intervals, tests and contingency tables. Elementary ANOVA. Relevant probabilistic concepts introduced as needed.

OS 2102 Introduction to Applied Probability for Electrical Engineering (4-1).
First course in probability. Structure of a probability model, density, distribution function, expectation and variance. Some basic models, Binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and central limit theorem. Transformations of random variables. PREREQUISITE: MA 1116 or equivalent.

OS 2103 Introduction to Applied Probability for Systems Technology (4-1).
First course in probability. Structure of a probability model, density, distribution function, expectation, variance. Basic models include binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and the central limit theorem. Functions of random variables. Stochastic processes. PREREQUISITE: MA 1116 or equivalent.

Upper Division or Graduate Courses

OS 3001 Operations Research for Computer Scientists (4-0).
An introduction to the methodology and techniques of operations research, with special emphasis on the computational aspects and on computer-related applications. Topics include linear programming, queueing theory, and PERT. Homework assignments include writing computer programs for some of the algorithms presented. PREREQUISITES: MA 2045, CS 0110, course in probability and statistics.

OS 3001 Operations Research for Computer Scientists (4-0).
An introduction to the methodology and techniques of operations research, with special emphasis on the computational aspects and on computer-related applications. Topics include linear programming, queueing theory, and PERT. Homework assignments include writing computer programs for some of the algorithms presented. PREREQUISITES: MA 2045, CS 0110, course in probability and statistics.

OS 3002 Operations Research for Naval Intelligence (4-0).
An introduction to the methodology and techniques of operations research, with special emphasis on specific areas relevant to naval intelligence such as decision-making under risk and uncertainity, forecasting, search, detection, resource allocation, and queues. PREREQUISITE: OS 3101 or equivalent.

OS 3003 Operations Research for Electronic Warfare (4-0).
This course deals with applications of quantitative models to operational electronic warfare problems, with the underlying idea being to make decisions by optimizing some measure of effectiveness (MOE). Topics covered include ESM, ECM/ECCM, strike warfare, ASMD, and cost-effectiveness tradeoffs. PREREQUISITES: Calculus and OS 2103.

OS 3004 Operations Research for Computer Systems Managers (5-0).
A one-quarter survey of operations research techniques of particular interest to students in computer systems management. Model formulation, decision theory, linear programming, project management techniques, inventory models, queueing and simulation, reliability and maintainability. Examples will illustrate the application of these techniques to the management of computer systems. PREREQUISITES: MA 2300, OS 3101.

OS 3005 Operations Research for Communications Managers (4-0).
A one-quarter survey of operations research techniques of particular interest to students in communications management. Model formulation, decision theory, games, linear programming, network flows, CPM and PERT, reliability and maintainability, queueing theory, and systems simulation. PREREQUISITES: MA 2300, OS 3101.

OS 3006 Operations Research for Management (4-0).
A survey of problem solving techniques for operations research. Topics include decision theory, linear programming, analysis of two-person games, Lanchester models of combat, project scheduling, inventory models, queueing models, and simulation. PREREQUISITES: MA 2300 and PS 3102.

OS 3007 Operations Research Methodology (4-0).
Survey of Operations Research techniques not covered in OS 3006. Topics may include simulation, search theory, extensions of combat models, network flows, and Markov chains. PREREQUISITES: OS 3103 and OS 3006 concurrently.

OS 3008 Analytical Planning Methodology (4-0).
A one-quarter survey of operations research techniques of particular interest to students in the C3 curriculum, with emphasis on model formulation. Topics include linear and nonlinear programming, integer programming, networks, flow shop and project scheduling, decision analysis, queueing and simulation.

OS 3090 Selected Topics in Management Science (2-0 to 5-0).
Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval. *Graded on Pass/Fail basis only.*

OS 3101 Statistical Analysis for Management (5-0).
A single course that covers the main statistical tools used in managerial applications for students with knowledge of fundamental probability concepts. Emphasis is placed on the development of standard statistical procedures introducing commonly encountered sampling distributions. Inference for Normal populations is developed to include both estimation and hypothesis testing. Following a development of regression models, selected nonparametric procedures are presented as an introduction to inference outside the restricted normal setting. PREREQUISITES: MA 2300 or equivalent and one or more couses in basic probability.

OS 3102-3103 Probability and Statistics for Management (3-0 and 4-0).
A specialized two-quarter sequence covering the basic probability and statistics with emphasis on managerial applications using the hand-held calculator. Computations are relegated to the calculator through specially prepared magnetic card programs coordinated to the textbook. Emphasis in the course is placed on modelling problems and interpreting results. Probability models studied include Bayes' theorem, reliability and life-testing, and sampling inspection. Random sampling is studied through the use of random number generator and the results are summarized by means of histograms, frequency tables and standard single characteristics. The usual inference for normal populations is developed with emphasis on interval estimation and hypothesis testing as an optional, but related, form. Analysis of variance is developed to include both one-way and two-way classifications, along with Scheffe's intervals for contrasts. The course ends with an extensive treatment of regression models including the standard simple linear model, multiple regression with three regressors, analysis of covariance along with a treatment of both simple and multiple correlation. A brief exposition of nonlinear regression is also presented. PREREQUISITES: MA 1110 and MA 2300 or equivalent.

OS 3104 Statistics for Science and Engineering (4-0).
Acquaint the engineering student with the techniques of statistical data analysis with examples from quality control, life testing, reliability and sampling inspection. Histograms and empirical distributions and random variables are introduced along with their probability distributions and associated characteristics such as moments and percentiles. Following a brief introduction to decision making, standard tests of hypotheses and confidence intervals for both one and two parameter situations are treated. Regression analysis is related to least squares estimation and associated tests of hypotheses and confidence intervals treated. Additional techniques of data analysis using nonparametric procedures are developed. Quality control charts are discussed as applications along with sampling inspection by attributes and by variables. PREREQUISITE: Calculus.

OS 3301 Systems Effectiveness Concepts and Methods (4-0).
An introduction to system reliability, maintainability, and effectiveness analysis. Failure (repair) rates and mean times to failure (repair). Models for aging and completion. Block diagrams and fault trees. Life testing. Availability, interval reliability, and the synthesis of reliability, maintainability, and effectiveness analysis. PREREQUISITES: OS 3102, OS 3103.

OS 3302 Introduction to Quality Assurance (4-0).
Characterization of quality requirements for material inspection procedures. Acceptance sampling, MIL-STD plans. Product and process quality cost analysis. Statistical control of quality. For students in management. PREREQUISITE: OS 3103.

OS 3303 Computer Simulation (4-1).
Introduction to computer simulation techniques such as Monte Carlo, time step and discrete event methods, with applications to ASW problems. PREREQUISITES: OS 3604 or equivalent (may be taken concurrently), and a working knowledge of FORTRAN programming.

OS 3304 System Simulation (4-1).
Computer simulation as a problem solving technique. Subject areas covered include: Discrete event digital simulation methodology, Monte Carlo techniques, simulation programming in FORTRAN and other available simulation languages, variance reduction techniques, design of simulation experiments and analysis of results. PREREQUISITES: CS 0110 or equivalent, OS 2102 or OS 2103 or equivalent.

OS 3401 Human Factors Engineering (3-0).
An introduction to human factors engineering for students in fields such as engineering. Designed to give the student an appreciation of man's capacities and limitations and how these can affect the optimum design of the man-machines system. Emphasis on integration of human factors into the system development cycle considering such topics as manpower/personnel costs, control and display design, human energy expenditure, physiological costs, and evaluation systems. PREREQUISITE: A previous course in probability and statistics.

OS 3402 Human Vigilance Performance (3-1).
Course involves an examination of man's attentiveness and capability in the detection of changes in stimulus events over prolonged periods of observation. Topics to be covered include theories of vigilance; task, signal, subject and environmental influences on performance; physiological and psychological responses and vigilance performance measurement. This course is designed for the ASW curriculum. PREREQUISITE: OS 3604.

OS 3403 Human Factors in EW (3-1).
This course will provide the student with the ability to evaluate and predict human performance in specified operational environments. The effects of stress factors such as noise, temperature, motion, workload, etc., on various aspects of human performance will be studied. Students will identify the control and display requirements or an EW system and design a workspace to accommodate an EW data reduction/analysis system.

OS 3404 Man-Machine Interaction (3-0).
An introduction to the man-machine interface problems in C3. Information, display and human communication requirements for effective C3. Applied orientation with student receiving his own computerized mailbox on the ARPANET enabling him to experience message handling systems, query languages, computer to computer communications between the U.S. and Europe, command and control applications programs, file transfer between host computers, etc. *Enrollment in C3 curriculum, or consent of Instructor required.*

OS 3601 Search, Detection, and Localization Models (4-0).
An introduction to the decision problems associated with Navy detection systems. The relation of detection models to search and localization models, measures of effectiveness of search/detection systems, and the optimum allocation of search effort are discussed. The last week of the course requires participation in an ASW related group project. This course is designed for the ASW curriculum. PREREQUISITE: OS 2103 and SECRET clearance.

OS 3602 Introduction to Combat Models and Weapons Effectiveness (4-1).
This course deals with the application of quantitative models to military problems. Topics include Lanchester's theory, game theory, reliability theory, systems effectiveness, and war gaming. This course is designed for the ASW curriculum. PREREQUISITES: OS 2103 and MA 2129.

OS 3603 Simulation and War Gaming (3-1).
Design, implementation and use of digital simulation models will be covered with special emphasis on features common to C3 and EW problems. War gaming will be discussed and a game using the digital computer will be played and critiqued by the class. Exercise planning and analysis will be treated. Basic topics are explained including computer generation of random variates, statistical design and monitoring of model progress, machine representation of dynamic data structures, model verification and validation on special purpose simulation and gaming languages. PREREQUISITES: CS 2810, CS 2811, OS 2103, OS 3604 or equivalent. TOP SECRET clearance required.

OS 3604 Decision and Data Analysis (4-0).
This course provides an introduction to the techniques of decision analysis, statistics and data analysis. It is primarily for students in the ASW, EW and C3 curricula. Emphasis is placed on the analysis of data and decision making in the ASW, EW and C3 environments. PREREQUISITES: OS 2103 or equivalent.

OS 3605 Command, Control and Communications Exercise Laboratory (C3 Lab) (2-4).
A course to enable the student to participate actively in the design, implementation and analysis of experiments and exercises examining command, control and communications systems or policies. Topics discussed and demonstrated include planning aids, decision support systems, operational decision aids, networking, situation displays, and distributed data bases. Laboratory exercises will be run in a war gaming environment to generate crisis situations for the purpose of evaluating C3 technologies, policies, C3 organization, information and intelligence. PREREQUISITES: CS 2105, CO 3111, OS 3402, OS 3404 and OS 3604 or consent of Instructor.

OS 3701 Requirements Determination for C3 (4-0).
The objective of this course is to enable the student to translate operational military requirements into functional capabilities of the system which can be directly addressed by the system engineers. Topics include military objectives, joint planning scenarios, joint military operations planning systems and their use in determining C3 requirements. The dimensions of performance, availability, communications security, interoperability, vulnerability, survivability, technical risk, cost, frequency conservation and flexibility are examined. Requirements evaluation techniques such as systems analysis, cost effectiveness and the PPBS and DOD acquisition systems are presented. Examples are taken from recent experience. PREREQUISITES: CO 3111, OS 3008. *Enrollment in C3 curriculum, or consent of Instructor required.*

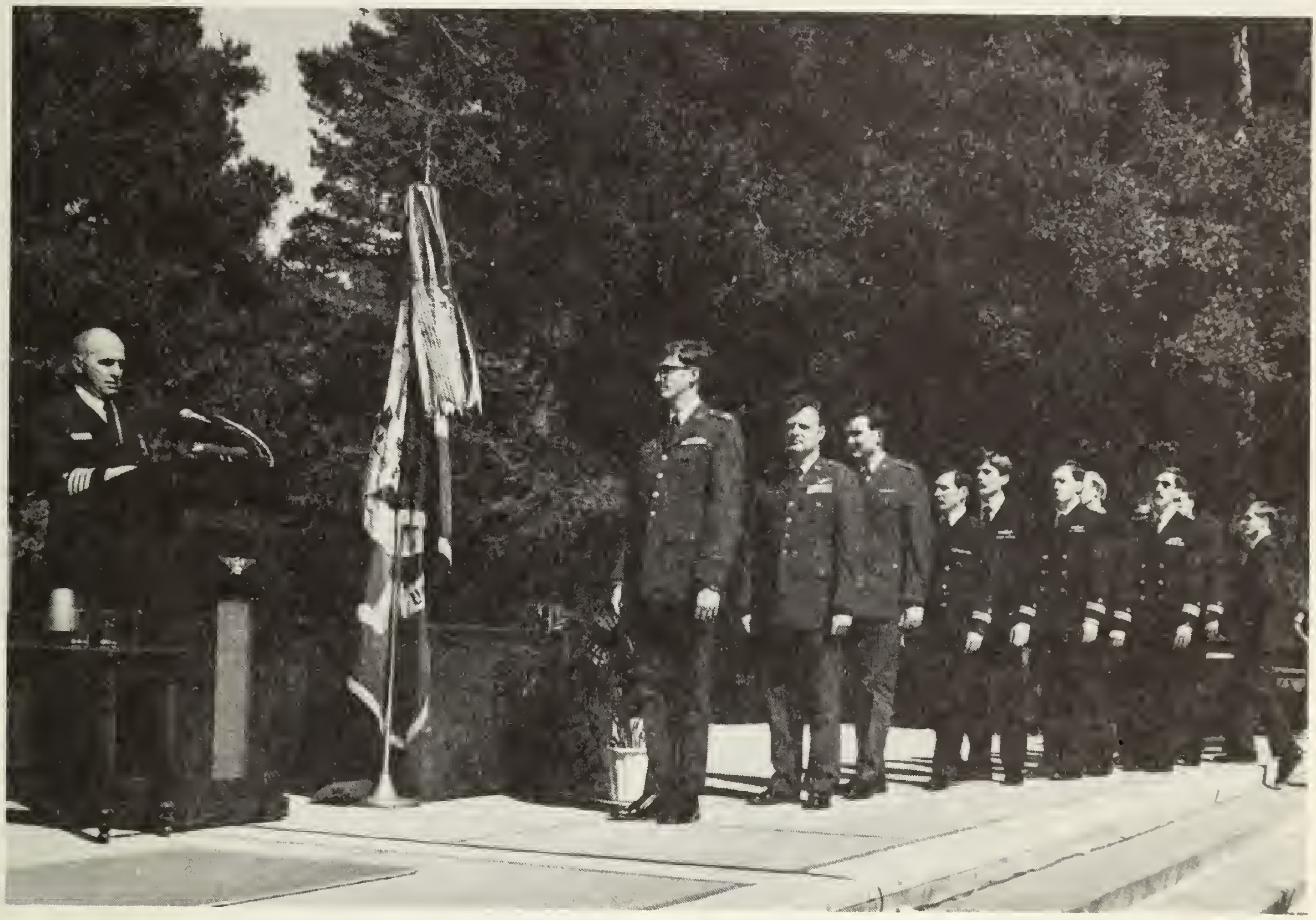
OS 3702 Manpower Requirements determination (4-0).
The objective is to enable the student to use some of the tools of industrial engineering in the determination of the quantity and quality of manpower required in military systems. Techniques include motion and time study, work sampling, predetermined time standards, work design and layout, materials handling, procedures review and process design. Applications for ship and squadron manning documents and SHORESTAMPS are included. PREREQUISITES: OS 3006 or OA 3201 and OA 3301.

Graduate Courses

OS 4301 Reliability, Maintainability, and Safety Analysis of Weapons Systems (4-0).
Modeling and measurement of factors contributing to system effectiveness. Reliability. Maintainability. Safety. Life and repair distributions for components, block diagrams, and fault trees. Estimation for components and systems. Optimal redundancy and repair. PREREQUISITES: OS 3104, OS 3604, AS 2701.

OS 4601 Test and Evaluation (4-0).
Designed for system technology students, this course examines problems associated with tests and evaluations of weapon systems and tactics. Included are concepts from experimental design, regression analysis, life testing, data analysis. Realistic data sets and examples are discussed and analyzed. PREREQUISITE: OS 3604.

OS 4701 Manpower and Personnel Models (4-0).
The objective of this course is to enable the student to make use of the major types of manpower and personnel models for estimating the effects of policy changes on the personnel system. Topics include longitudinal and cross-section models, optimization models, data requirements and validation. Applications in the form of current military models are included. PREREQUISITE: OS 3006 or OA 3201 and OA 3301.



Graduation exercises, June 1981

DEPARTMENT OF PHYSICS AND CHEMISTRY

Physics professors studying finite-amplitude acoustic waves

John Norvell Dyer, Distinguished Professor of Physics; Chairman (1961)*; B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

Robert Louis Armstead, Associate Professor of Physics (1964); B.S., Univ. of Rochester, 1958; Ph.D., Univ. of California at Berkeley, 1964.

Charles Lyman Burmaster, Instructor in Physics (1981); B.S.E.E., Arizona State Univ., 1966; M.S., Naval Postgraduate School, 1977.

Fred Ramon Buskirk, Professor of Physics (1960); B.S., Western Reserve Univ., 1951; Ph.D., Case Institute of Technology, 1958.

Alfred William Madison Cooper, Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's Univ. of Belfast, 1961.

John Niessink Cooper, Professor of Physics (1956); B.A. Kalamazoo College, 1935; Ph.D., Cornell Univ., 1940.

Alan Berchard Coppens, Associate Professor of Physics (1964); B. Eng. Phys., Cornell Univ., 1959; M.S., Brown Univ., 1962; Ph.D., 1965.

Eugene Casson Crittenden, Jr., Distinguished Professor of Physics (1953); B.A., Cornell Univ., 1934; Ph.D., 1938.

Harvey Arnold Dahl, Assistant Professor of Physics (1964); B.S., Stanford Univ., 1951; Ph.D., 1963.

Harry Elias Handler, Professor of Physics (1958); B.A., Univ. of California at Los Angeles, 1949; M.A., 1951; Ph.D., 1955.

Don Edward Harrison, Jr., Professor of Physics (1961); B.S., College of William and Mary, 1949; M.S., Yale Univ., 1950; Ph.D., 1953.

Otto Heinz, Professor of Physics (1962); B.A., Univ. of California at Berkeley, 1948; Ph.D., 1954.

Raymond Leroy Kelly, Professor of Physics (1960); B.A., Univ. of Wichita, 1947; M.S., Univ. of Wisconsin, 1949; Ph.D., 1951.

Herman Medwin, Professor of Physics (1955); B.S., Worcester Polytechnic Institute, 1941; M.S. Univ. of California at Los Angeles, 1948; Ph.D., 1953.

Edmund Alexander Milne, Associate Professor of Physics (1954); B.A., Oregon State College, 1949; M.S., California Institute of Technology, 1950; Ph.D., 1953.

John Robert Neighbours, Professor of Physics (1959); B.S., Case Institute of Technology, 1949; M.S., 1951; Ph.D., 1953.

William Reese, Professor of Physics/Defense Technology (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

Richard Alan Reinhardt, Professor of Chemistry (1954); B.S., Univ. of California at Berkeley, 1943; Ph.D., 1947.

George Wayne Rodeback, Associate Professor of Physics (1960); B.S., Univ. of Idaho, 1943; M.S., Univ. of Illinois, 1947; Ph.D., 1951.

James Vincent Sanders, Associate Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

Gordon Everett Schacher, Professor of Physics (1964); A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

Fred Richard Schwirzke, Associate Professor of Physics (1967); B.S., Univ. of Rostock, 1950; M.S., Univ. of Karlsruhe, 1953; Ph.D., 1959.

Oscar Bryan Wilson, Jr., Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

Karlheinz Edgar Woehler, Professor of Physics (1962); B.S., Univ. of Bonn, 1953; M.S., Technical Univ., Aachen, 1955; Ph.D., Univ. of Munich, 1962.

William Bardwell Zeleny, Associate Professor of Physics (1962); B.S., Univ. of Maryland, 1956; M.S., Syracuse Univ., 1958; Ph.D., 1960.

Emeritus Faculty

Newton Weber Buerger, Professor Emeritus (1942); B.S., Massachusetts Institute of Technology, 1933; M.S., 1934; Ph.D., 1939.

Austin Rogers Frey, Distinguished Professor Emeritus (1946); B.S., Harvard Univ., 1930; M.S., 1924; Ph.D., 1929.

William Wisner Hawes, Professor Emeritus (1952); B.S., Ch. Eng., Purdue Univ., 1924; Sc.M., Brown Univ., 1927; Ph.D., 1930.

Sydney Hobart Kalmbach, Professor Emeritus (1947); B.S., Marquette Univ., 1934; M.S., 1937.

Gilbert Ford Kinney, Distinguished Professor Emeritus (1942); A.B., Arkansas College, 1928; M.S., Univ. of Tennessee, 1930; Ph.D., New York Univ., 1935.

George Daniel Marshall, Jr., Professor Emeritus (1946); B.S., Yale Univ., 1930; M.S., 1932.

George Harold McFarlin, Professor Emeritus (1948); B.A., Indiana Univ., 1925; M.A., 1926.

Leonard Oliver Olsen, Professor Emeritus (1960); B.A., Iowa State Teachers College, 1932; M.S., State Univ. of Iowa, 1934; Ph.D., 1937.

Melvin Ferguson Reynolds, Professor Emeritus (1949); B.S., Franklin and Marshall College, 1932; M.S., New York Univ., 1935; Ph.D., 1937.

John Dewitt Riggin, Professor Emeritus (1946); B.S., Univ. of Mississippi, 1934; M.S., 1936.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEGREE REQUIREMENTS

The Department of Physics and Chemistry offers the MS and BS degrees in Physics and in Engineering Science. In addition, the Ph.D. is offered by the Department. Upon approval by the Department, courses taken at other institutions may be applied towards satisfying degree requirements.

MASTER OF SCIENCE IN PHYSICS

1. A candidate for the degree Master of Science in Physics must complete satisfactorily a program of study which includes a minimum of 30 quarter hours of physics courses (not including thesis) distributed among courses at the graduate level; of this 30 hours at least 15 hours must be at the 4000 level. Upon approval of the Chairman of the Physics and Chemistry Department a maximum of 4 hours of courses taken in another department may be applied toward satisfying the above requirements. In lieu of the preceding requirement, students who are qualified to pursue graduate courses in physics when they arrive at the Postgraduate School may complete a minimum of 20 hours entirely of 4000 level physics courses. In addition, all students must present an acceptable thesis.

2. The following specific course requirements must be successfully completed for a student to earn the degree of Master of Science in Physics:
   a. Thermodynamics and Statistical Mechanics — the student must take a two-quarter sequence or present equivalent preparation in this area.
   b. A course in Advanced Mechanics or Quantum Mechanics.
   c. A course in Electromagnetism at the 4000 level.
   d. An advanced course in Modern Physics.
   e. Specialization, to include at least two advanced courses in an area of specialization.

3. Programs leading to the Master of Science degree in Physics must be approved by the Chairman of the Department of Physics and Chemistry.

MASTER OF SCIENCE IN ENGINEERING SCIENCE

Students of the Weapon Systems Engineering Curriculum (530) who elect a Physics area as their specialization option will receive the degree Master of Science in Engineering Science. The program must include at least 36 credit hours of graduate work in engineering, science and mathematics, at least 12 of which must be at the 4000 level. Of these 36 hours, at least 20 hours, including work at the 4000 level, must be in the Department of Physics and Chemistry. This will be the major department, and cognizance over the specialization course sequences, thesis research areas and the degree resides with the Chairman of the Department of Physics and Chemistry.

In addition to the major, the program must contain at least 12 hours at the graduate level in courses representing areas other than the major.

The candidate must present an acceptable thesis on a topic given prior approval by the Department of Physics and Chemistry. Final approval of the program leading to the Master of Science in Engineering Science with major in Physics shall be obtained from the Chairman of the Department of Physics and Chemistry.

DOCTOR OF PHILOSOPHY

The Ph.D. degree is offered in the Department in several areas of specialization which currently include Acoustics, Atomic Physics, Solid State Physics, Theoretical Physics, Nuclear Physics and Plasma Physics.

Requirements for the degree may be grouped into 3 categories: courses, thesis research and examinations in major and minor fields.

The required examinations are outlined under the general school requirements for the Doctor's degree. In addition to the school requirements the department requires a preliminary examination to show evidence of acceptability as a doctoral student.

The usual courses to be taken by the candidate include Advanced Mechanics, Classical Electrodynamics, Quantum Mechanics and Statistical Physics. (PH 4171, 4371, 4971, 4972, 4973, 4571, 4572). Suitable electives are to be chosen in physics and the minor fields, mainly from the list of graduate level courses.

PHYSICS AND CHEMISTRY LABORATORIES

The physics laboratories are equipped to carry on instructional and research work in atomic physics, nuclear physics, solid state physics, electro-optics, plasma physics, spectroscopy, and acoustics.

A 100-MeV electron linear accelera- with 5-microamp beam current is used in radiation studies.

The electro-optics laboratory uses imaging and detecting systems from the far infrared to the visible range including instrumentation for seagoing experiments in optical propagation. The laser laboratory contains a giant pulse laser and associated detection equipment for the visible spectrum as well as a high power laser in the IR region.

The plasma physics laboratory includes a plasma system, diagnostic equipment for studies of plasma dynamics, and a steady state plasma source with magnetic fields to 10,000 gauss.

The spectroscopy equipment includes a large grating spectrograph, a large prism spectrograph, and an infrared spectrophotometer. The spectroscopic data center contains a comprehensive compilation of the known energy levels and atomic spectral lines in the vacuum ultraviolet range.

The acoustics laboratory equipment includes a large anechoic chamber, a small reverberation chamber, and a multiple-unit acoustics laboratory for student experimentation in airborne acoustics. Sonar equipment, test and wave tanks, and instrumentation for investigation in underwater sound comprise the underwater acoustics laboratory.

DEPARTMENTAL COURSE OFFERINGS

PHYSICS

PH 0110 Refresher Physics (5-3).
NON-CREDIT. A six-week refresher course of selected topics from elementary mechanics for incoming students. Typical topics are kinematics, Newton's Laws, the concepts of work, energy, and linear momentum, and simple harmonic motion. Vector algebra and some aspects of calculus are developed as needed and their use is emphasized. The two ninety-minute laboratory periods are devoted to guided problem solving. PREREQUISITES: Previous college courses in elementary physics and integral calculus.

PH 0499 Acoustics Colloquium (0-1).
Reports on current research and study of recent research literature in conjunction with the student thesis. PREREQUISITE: A course in acoustics.

PH 0810 Thesis Research (0-0).
Every student conducting thesis research will enroll in this course.

PH 0999 Physics and Chemistry Colloquium (0-1).
Discussion of topics of current interest by NPS and outside guest speakers.

The BASIC PHYSICS sequence, PH 1011, PH 1012 is equivalent to the standard university level calculus-based introductory courses in mechanics and electricity and magnetism. Normally the student is expected to have adequate preparation in these areas at the time of matriculation at NPS; however, these courses are available upon demand for students with partial or no background in basic physics.

The mini-courses PH 1061 through Ph 1066 comprise a Basic Physics sequence available in the self-instructional (PSI) mode for both on-campus and off-campus use.* Various combinations of these mini-courses are essentially equivalent to, and may be substituted for, the courses PH 1011, PH 1012, and PH 1041, as follows:

Campus Course	*Equivalent mini-course Sequence*
PH 1011	PH 1061, 1062, 1063
PH 1012	PH 1064, 1065, 1066
PH 1041	PH 1061, 1062, 1064 1065, 1066

**The mini-courses are described in the Continuing Education catalog.*

Lower Division Courses

PH 1011 Basic Physics I — Mechanics (4-2).
Vector algebra, particle kinematics in one and two dimensions; Newton's Laws; particle dynamics; work, kinetic and potential energy, conservation of energy; conserva- of linear momentum; oscillations; gravitation; rotational kinematics and dynamics, conservation of angular momentum. PREREQUISITE: A course in calculus or concurrent registration in a calculus course. *The lab hours may either be laboratory or problem sessions depending on the needs of the students.*

PH 1012 Basic Physics II — Electricity and Magnetism (4-2).
Electric charge, Coulomb's Law, electric field and potential, Gauss's Law, capacitors and dielectrics, current and resistance, sample circuits, EMF, magnetic field, Ampere's and Faraday's Laws, inductance, electromagnetic oscillations and waves. Maxwell's Equations. PREREQUISITE: PH 1011 or equivalent. *The lab hours may either be laboratory or problem sessions depending on the needs of the students.*

PH 1041 Review of Basic Physics (3-1 or 5-1).
Kinematics, Newton's Laws, potential energy concept, energy and momentum conservation. Electric fields, Coulomb's and Gauss' Law, magnetic fields, Ampere's and Faraday's Law. Integral form of Maxwell's Equations. PREREQUISITE: A previous course in general physics and a course in calculus. *Taught as 3-1 only for students who have completed mechanics portion.*

Upper Division Courses

PH 2119 Oscillations and Waves (3-1).
An introductory course designed for the Antisubmarine Warfare curriculum. The course covers kinematics and dynamics of particle motion in gravitational fields; work and energy; the damped, driven harmonic oscillator and resonance; and an introduction to wave motion including interference. PREREQUISITE: MA 2129 or equivalent.

PH 2123 Basic Physics: Waves and Optics (4-0).
A course to provide physical background to wave motion, acoustics, and optics for students in the Electronic Warfare curriculum, and to provide applications of analytical techniques to physical problems. Areas covered are harmonic motion - differential equations, complex notation, damped vibration and resonance; wave motion — properties of waves, sound waves, electromagnetic waves, light waves; optics — geometrical and wave optics. PREREQUISITES: MA 1112, MA 2129 and MA 2181 taken concurrently.

PH 2124 Basic Physics: Electromagnetism and Electromagnetic Waves (2-0).
This course normally follows PH 2123. Basic electromagnetism is introduced leading to Maxwell's equations. The wave properties resulting from these equations are treated for simple propagation geometries. PREREQUISITE: PH 2123 or equivalent.

PH 2151 Mechanics I — Particle Mechanics (4-1).
After a review of the fundamental concepts of kinematics and dynamics, this course concentrates on those two areas of dynamics of simple bodies which are most relevant to applications in Weapon Systems Engineering: vibrations and projectile motion. Topics include: damped and driven oscillations, rotating coordinate systems, projectile motion with atmospheric friction, and satellite orbits. PREREQUISITE: PH 1041 or equivalent.

PH 2241 Modern Physics for Engineers (4-0).
An introductory course intended to impart a broad background in modern physics. The couse begins with a brief review of classical mechanics and electromagnetism, followed by atomic and molecular structure and spectra. Black body radiation, photoelectric effect, emission and absorption of radiation by atoms and molecules, and the energy band architecture of solids lead to an introduction to applications in lasers, semiconductors, and microwave devices. Applications may be tailored to suit the interests of the instructor and the class. PREREQUISITE: Elementary calculus and a course in basic physics, or consent of the Instructor.

PH 2251 Physical Optics and Introductory Modern Physics (4-2).
A course designed to provide the fundamental ideas of wave theory, physical optics, and introductory modern physics. Topics covered include the wave equation, phase and group velocity, Fresnel's equations, Fourier transforms, interference, diffraction, polarization, birefringence, black-body radiation, special theory of relativity, the photon, photoelectric effect and Compton scattering. Bohr atom, de Broglie hypothesis, Schroedinger equation, infinite and finite square well. A laboratory is included. PREREQUISITE: PH 1041. *(May be taken through Continuing Education as mini-courses PH 2253-55.)*

PH 2265 Geometrical Optics (2-2).
The course first introduces geometrical optics; reflection and refraction of rays at plane and spherical surfaces; mirrors, plane and spherical; lenses, thick lenses and lens aberration; matrix methods for thick lenses and lens systems. A laboratory is included. Subjects to be covered include laboratory procedures, definition of measurement, random and systematic errors, propagation of uncertainties, graphical and analytical treatment of data, statistical concepts, focal length of lens and mirror, refractive index of glass, thick lens, optical instruments, optical spectra, and prism spectrometer. PREREQUISITE: A course in basic physics.

PH 2270 Fundamentals of Electro-Optics (4-0).
This course is designed to provide the background knowledge for electro-optics to students in interdisciplinary curricula. Topics discussed include: matrix formulation of optics, catoptric and catadioptric systems, diffraction, behavior of gaussian profile beams, Fourier optics and resolution, atmospheric transmission, atomic and molecular energy states, line shpaes, band theory of semiconductors, the p-n junction, light emitting diodes, stimulated emission, and lasers. PREREQUISITES: MA 3139 and PH 2124 (or equivalent).

PH 2351-2352 Electromagnetism I-II (4-1) and (4-0).
Properties of electric and magnetic fields and the development of Maxwell's Equations (for static fields); electrostatic fields and potential in free space and dielectrics, the magnetic fields and potentials of steady currents in free space and permeable materials, electromagnetic induction, Maxwell's Equations, and Poynting's Theorem. Faraday's law and the general Maxwell equations; properties of electromagnetic waves: wave equations; propagation of plane waves in free space, dielectrics, conductors, and plasmas; reflection and refraction of plane waves; two-conductor transmission lines; rectangular wave guides. A condensed version of this course, with emphasis on wave propagation is available as PH 3360. PREREQUISITE: PH 1041.

PH 2471 Introduction to the Sonar Equations (3-0).
A discussion of each term of the sonar equations, with application to the detection, localization, and classification of underwater vehicles. Topics include ray acoustics, simple transmission loss models, tonals, spectrum and band levels, directivity index, array gain, doppler shift, and detection threshold. This course is intended primarily for students in the Antisubmarine Warfare curriculum. PREREQUISITE: Precalculus mathematics. *(May be taken through Continuing Education as mini-courses PH 2474-76).*

PH 2810 Survey of Nuclear Physics (4-0).
An introduction to the basic concepts of nuclear physics with emphasis on neutron physics and nuclear reactors. Atomic nature of matter, wave-particle duality, energy levels. Basic nuclear properties, radioactivity, neutron reactions. Elements of fission and fusion reactors.

Upper Division or Graduate Courses

PH 3152 Mechanics II — Extended Systems (4-1).
The principles of dynamics are applied to real extended bodies. Topics include: principles of rocket propulsion, rotational motion of axisymmetric bodies and its application to projectile spin and gyroscopic motion. An introduction to generalized methods of description of dynamic systems is given and the general behavior of complex vibrating systems is studied. PREREQUISITE: PH 2151.

PH 3161 Fluid Dynamics (4-1).
This course emphasizes the dynamics of real fluids. The basic properties of fluids are introduced, and the concepts of fluid kinematics, stress, and strain are discussed. Both the control-volume and differential equation approaches are applied to the flow of a viscous fluid. Topics covered include: laminar flow, turbulent flow, boundary layer theory, and the calculation of lift and drag. The laws of similarity are developed, and the significance of Reynolds, Froude, and Mach numbers discussed. Compressible flow topics covered include isentropic subsonic channel flow and supersonic flow in nozzles. PREREQUISITE: PH 2151 or equivalent.

PH 3271 Electro-Optic Principles and Devices (4-0).
This course is designed to provide students in interdisciplinary programs with an understanding of the principles and capabilities of the component devices comprising military electro-optic and infrared systems. Topics treated include: atmospheric extinction, turbulence effects on optical transmission and imaging, thermal blooming and breakdown, adaptive optics, thermal radiation, target signatures, backgrounds, modulators and shutters, beam steerers, reticles, detector characteristics and types, detector noise and cooling, imaging detectors for intensifiers, television and FLIR, CCD and CID devices, and displays. PREREQUISITES: PH 2270 and MR 2416 or equivalent.

PH 3281 Non-Acoustic Sensor Systems (4-0).
This course covers the physical principles underlying the operation of a number of operational and proposed non-acoustic sensor systems. Geomagnetism, magnetometers and gradiometers, MAD signatures, optical and IR transmission in the atmosphere and in sea water. FLIR and radar systems for ASW. Exotic detection schemes. PREREQUISITES: PH 3366, EE 3714, SECRET clearance.

PH 3321 Radiation Systems (4-0).
This course for students of Operations Research and other Weapon System oriented non-engineering curricula discusses the physical principles exploited by information gathering systems with emphasis on general capabilities and limitations. After a general introduction to wave propagation, topics of discussion are electromagnetic waves, radar, electro-optics including lasers, and underwater sound. These topics will be applied to specific systems such as missile guidance, sonobouys, and phased arrays, as appropriate to the class and instructor. PREREQUISITES: MA 1116 or equivalent may be taken concurrently, or by consent of Instructor.

PH 3360 Electromagnetic Wave Propagation (4-1).
After an analytical introduction to electromagnetic field theory, the course concentrates on properties of electromagnetic wave propagation and the phenomena of radio and radar transmission, including special topics on antennas and waveguides. PREREQUISITES: MA 3139, PH 1041, and an introduction to vector analysis.

PH 3366 Electromagnetic Wave Propagation (4-0).
This course is designed for the ASW curriculum and may be taught as an accelerated 6-week course. An introduction to Maxwell's equations and the basic properties of electromagnetic wave propagation in various media and the interface between media. These concepts are applied to wave propagation in the sea, the atmosphere and the ionosphere. Basic properties of antennas and waveguides. PREREQUISITES: A basic course in electricity and magnetism, vectors, and differential equations.

PH 3431 Physics of Sound in the Ocean (4-2).
A survey of physical acoustics with emphasis on the generation, propagation, and detection of sound in the ocean. Topics include: damped and forced harmonic oscillations; the acoustic wave equation and its limitation in fluids; solutions for plane and diverging waves; ray acoustics; radiation of sound; reflection from boundaries; normal mode propagation in the ocean; effects of inhomogeneities and sound absorption; term by term analysis of the sonar equations emphasizing transmission loss models and detection threshold models; properties of transducers for underwater sound. Laboratory experiments include surface interference, spectral analysis of noise, normal modes, waveguides, and acoustical sources. PREREQUISITES: A course in general physics, a course in differential equations, and working knowledge of complex exponential notation.

PH 3451 Fundamental Acoustics (4-1).
Mechanics of free, forced, and damped simple vibratory systems, mechanical impedance. Development of, and solutions to the acoustic wave equations in extended media. Propagation of plane waves in fluids and between media. Acoustical behavior of sources and arrays. Radiation impedance. Introduction to transducers. Laboratory experiments on selected topics. PREREQUISITES: A course in mechanics (e.g., PH 2151); differential equations (e.g., MA 2121).

PH 3452 Underwater Acoustics (4-2).
Lumped acoustic elements and propagation in pipes. Steady state response of acoustic waveguides. Group and phase speeds. Normal modes. Sound absorption and dispersion for classical and relaxing fluids. Transmission of sound in the ocean; the eikonal equation and necessary conditions for ray acoustics, method of images, refraction and ray diagrams, mode propagation in shallow water and refraction channels. Ambient noise and reverberation. Target strength. The sonar equations for active and passive systems.. Laboratory experiments on selected concepts. PREREQUISITE: PH 3451.

PH 3458 Noise, Shock and Vibration Control (4-0).
The application of the principles of acoustics and mechanics to the problem of controlling noise, vibration and mechanical shock. Topics include: Linear mechanical vibrations, introduction to vibrations of non-linear systems; damping mechanisms; vibration and shock isolation; noise generation and control; effects of noise on man; application to problems of Naval interest such as ship quieting and industrial noise control. PREREQUISITE: A course in acoustics.

PH 3461 Explosives and Explosions (4-1).
Explosives terminology; manufacturing and testing of high explosives; thermochemistry of explosive decompositon; the detonation state. Generation and propagation of explosive shock waves in air and water including Rankine-Hugoniot equations, scaling laws, reflection and refraction phenomena, and experimental data. Shock loads on ships and blast loads on structures. Damage mechanism and principles of protection against damage. PREREQUISITE: CH 2404.

PH 3463 Special Topics in Underwater Acoustics and Sound (3-2).
Special topics of interest in the areas of underwater sound, transduction, propagation and detection, depending on the interests and needs of the students. PREREQUISITE: PH 3431 or PH 3452 or PH 3472.

PH 3472 Underwater Acoustics (4-2).
In this course, the second of the three-course sequence for students in the ASW curriculum, an analytical study is made of the underwater acoustics that affect the sonar equations. Topics include: the wave equation; acoustic properties of fluids; plane, spherical, and cylindrical waves; behavior of sources and arrays; reflection and transmission at boundaries; elementary properties of transfucers; image theory; layers and the shallow water channel; propagation in wave guides; normal mode propagation. This course is taught in coordination with OC 3265. PREREQUISITES: PH 2471 and concurrent enrollment in OC 3265.

PH 3561 Introductory Statistical Physics (4-0).
Distribution functions, kinetic theory, transport processes, introduction to classical and quantum distributions. Applications to gases, solids, and radiation. PREREQUISITES: PH 3152, PH 3651, CH 2401 or 2404.

PH 3600 Weapons Systems and Weapons Effects (4-0).
The course will cover technical aspects of three areas of modern weapons systems: warheads, weapon targeting, and electronic

warfare. Topics are: elements of nuclear weapons; nuclear weapon effects on personnel, equipment, and structures; conventional warhead effects; targeting considerations; over-the-horizon detection classification and targeting problems; principles of electromagnetic warfare. PREREQUISITE: PH 3321 or equivalent.

PH 3651 Atomic Physics (4-2).
The Schroedinger equation. Free states, the square well and the hydrogen atom. Electron spin. The exclusion principle and the periodic table. Multi-electron atoms, the vector model, coupling schemes. Zeeman effect. Transitions, Einstein coefficients, lasers. The Kronig-Penny model and band theory of solids. Semiconductors. There is a lab included. PREREQUISITE: PH 2251.

PH 3687 Physics of Electron Interaction in Gases (3-0).
This course stresses the basic electronic processes in gases, fundamental to the physics and chemistry of the upper atmosphere and to the operation of electron devices including the gas laser. Topics covered include elastic collisions, free and ambipolar diffusion, mobility, excitation and ionization, charge transfer emission from surfaces, recombination high frequency, d c, and laser breakdown, sheaths, the glow and arc discharges, radiation, application to the gas laser. PREREQUISITE: PH 3651 or consent of Instructor.

PH 3951 Quantum Mechanics (4-0).
The foundation of quantum mechanics and its relation to classical mechanics is studied in depth, enabling the student to obtain a basic understanding of the quantum phenomena investigated in subsequent courses in atomic physics, nuclear physics, electro-optics, etc. Selected applications. PREREQUISITES: PH 2251 and PH 3152.

PH 3952 Electro-Optics (4-0).
This course treats the properties of electro-optic systems together with the basic physical principles involved. Topics included are: diffraction and Fourier transform methods; optical data processing; holography; Fresnel equations, evanescent waves, film and fiber optics; Gaussian beams and laser resonators; molecular spectra, transition probability, line widths, and laser gain; specific lasers, Q-switching and mode locking; semiconductors, Brillouin zones, junction diodes, photodetection, light emitting diodes and diode lasers. PREREQUISITE: PH 3651.

PH 3998 Special Topics in Intermediate Physics (1-0 to 4-0).
Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interest of students. The course may be conducted as seminar or supervised reading. It carries a letter grade and may be repeated in different topics. PREREQUISITE: Consent of the Department Chairman. *The course may also be taken on the Pass/Fail basis provided the student has requested so at the time of enrollment.*

Graduate Courses

PH 4171 Advanced Mechanics (4-0).
Hamilton's Principle. The equations of motion in Lagrangian and Hamiltonian form. Symmetries and constants of the motion. The inertia tensor and rigid bodies. Canonical transformation and Poisson brackets. Small oscillations. PREREQUISITES: PH 3152, PH 3360 or equivalent.

PH 4283 Laser Physics (4-0).
The physics of lasers and laser radiation. Topics will include: spontaneous and stimulated emission, absorption, interaction of radiation with matter, line broadening mechanisms, optical and electrical pumping, gain, properties of laser beams, Gaussian beams, stable and unstable resonators, rate equations, output coupling, mode locking, short pulsing, specifics of solid state and gas laser systems, high energy and high power lasers, applications of lasers, laser-surface interaction, air breakdown, laser supported detonation waves, laser isotope separation, and laser fusion. PREREQUISITE: PH 3952 or equivalent, or consent of Instructor.

PH 4363 Topics in Advanced Electricity and Magnetism (4-0).
Topics selected from: scattering and absorption of waves by single particles; multiple scattering and radiation transport through random media; relativistic formalism and radiation from accelerated charges; propagation in layered conducting media such as the atmosphere, sea water, ocean floor systems. PREREQUISITES: PH 3360 or PH 2352 and MA 3132 or equivalent.

PH 4371 Classical Electrodynamics (3-0).
Tensors in special relativity. Classical relativistic electromagnetic field theory. Lorentz electron theory. PREREQUISITES: PH 4363 and familiarity with the special theory of relativity and Lagrangian mechanics.

PH 4400 Advanced Acoustics Laboratory (0-6).
Advanced laboratory projects in acoustics. PREREQUISITE: PH 3452 or equivalent.

PH 4453 Radiation and Scattering of Waves in Fluids (4-0).
An advanced treatment of special topics related to sound propagation in the ocean, including: multipole radiation fields, scattering from spheres, scattering from inhomogeneities and rough surfaces, propagation in the presence of internal ocean waves. PREREQUISITE: PH 3452 or consent of Instructor.

PH 4454 Transducer Theory and Design (3-2).
A treatment of the fundamental phenomena basic to the design of transducers for underwater sound, specific examples of their application and design exercises. Topics include piezoelectric, magnetostrictive and hydromechanical effects. Laboratory includes experiments on measurement techniques, properties of transducer materials, characteristics of typical transducer types, and a design project. PREREQUISITE: PH 3452, or consent of Instructor.

PH 4456 Seminar in Application of Underwater Sound (3-0).
A study of current literature on application of acoustics to problems of Naval interest. PREREQUISITE: PH 3431 or 3452 or 3473.

PH 4459 Shock Waves and High-Intensity Sound (3-0).
Nonlinear oscillations and waves on strings. The nonlinear acoustic wave equation and its solution. The parametric array. The physics of shock waves in air and in water. PREREQUISITE: PH 3451.

PH 4473 Advanced Topics in Underwater Acoustics (4-0).
The last course in the acoustics sequence for students in the ASW curriculum, it is in part, a continuation of the preceding course, PH 3472. Topical content will vary somewhat depending upon the background and interests of the students, it shall include: normal mode propagation in the ocean and transmission loss models in shallow water; reflection from liquid-solid boundaries with an introduction to realistic models for bottom reflectivity and target strength, and to noise and vibration control aboard ships. Other topics may include current developments in variability of target strength and of radiated noise, scattering from rough surfaces, optimum frequencies for sonar, coatings for reducing reflectivity, and parametric generation of sound. PREREQUISITE: PH 3472 or consent of Instructor, and SECRET clearance.

PH 4571-4572 Statistical Physics I-II (3-0).
Kinetic theory and the Boltzmann theorem, configuration and phase space, the Liouville theorem, ensemble, theory, microcanonical, canonical and grand canonical ensembles, quantum statistics. Application to molecules, Bose-Einstein gases, Fermi-Dirac liquids, and irreversible processes. PREREQUISITES: PH 3152, 3651, CH 2401 or 2404.

PH 4631 Introduction to Astrophysics (4-0).
Introduction to theories of stellar structure, energy trtansport in stars, and stellar evolution. Recent advances in astrophysics will be discussed. PREREQUISITE: Consent of Instructor.

PH 4661 Plasma Physics I (4-0).
This course constitutes a broad study of the behavior and properties of gaseous plasma, the fourth — and most abundant — state of matter in the universe. Plasma physics is a vigorously developing branch of contemporary physics. Its many applications are in areas such as astro and space-physics, atomic physics, magneto-hydrodynamic power generation, electron beam excited laser, laser isotope enrichment, ionospheric communication, thermonuclear fusion, and high energy beam weapons. The physical concepts fundamental to various branches of plasma physics are introduced. Topics covered include single particle motions in electromagnetic fields, orbit theory, collision phenomena, breakdown in gases, and diffusion. The magnetohydrodynamic and the two-fluid plasma models are considered. PREREQUISITES: PH 3360, PH 3561, PH 3651, or the equivalent.

PH 4662 Plasma Physics II (3-0).
A continuation of Plasma Physics I. Applications of the hydromagnetic equations to the study of macroscopic motions of plasma. Equilibrium and stability. Classification of plasma instabilities. Kinetic theory, the Boltzmann equation and the macroscopic momentum transport equation. Plasma oscillations and Landau damping. Nonlinear effects, shock waves, radiations from plasma, including bremsstrahlung and cyclotron radiation. Controlled fusion and laser produced plasmas. PREREQUISITES: PH 4363, PH 4661 or equivalent.

PH 4681 Advanced Plasma Physics (3-0).
Selected topics in plasma physics, such as laser-target interaction, dynamics of a laser-produced plasma, self-generated magnetic fields, plasma surface interactions, unipolar arcing, light scattering and absorption in plasma, turbulence and fluctuations, collisionless shock waves. PREREQUISITE: PH 4662 or consent of Instructor.

PH 4685 Advanced Atomic Physics (3-0).
Selected topics in atomic spectroscopy and atomic collisions. Classical and quantum description of the collision process, transition probabilities and line broadening mechanisms. PREREQUISITE: PH 3651 and consent of Instructor.

PH 4750 Radiation Effects in Solids (4-2).
Energy loss of radiation in matter, radiation dosimetry, energy transfer of radiation to matter, theory and spectra of radiation from nuclear weapons, fireball development, electromagnetic pulse phenomena, displacements of atoms in solids, radiation damage to solid-state devices. PREREQUISITES: PH 2810, 3360, and 3651, or equivalents.

PH 4760 Solid State Physics (4-0).
Fundamental theory and related laboratory experiments dealing with solids: crystals, binding energy, lattice vibration, dislocations and mechanical properties, free electron theory, band theory, properties of semiconductors and insulators, magnetism. PREREQUISITE: PH 3651.

PH 4851 Nuclear Physics (4-0).
Nuclear decay schemes and energetics; nuclear forces; the deuteron and low energy electron-nucleon scattering; partial wave and analysis of scattering; neutron-induced reactions and the Breit-Wigner formula; beta and gamma decay; and Q-value in reactions. PREREQUISITES: PH 3651, and PH 3360.

PH 4881 Advanced Nuclear Physics (3-0).
Topics selected from: relativistic mechanics, scattering of electrons from nuclei, nuclear models, nuclear potentials, relativistic treatent of the electron using the Dirac equation and application to electron scattering to develop the Mott cross-section; treatment of form-factors arising from electron-nucleon and electron-nucleus scattering; application of electron scattering to study the structure of nucleon matter and the study of nucleon models. PREREQUISITE: PH 4851.

PH 4885 Reactor Theory (3-0).
The diffusion and slowing-down of neutrons. Homogeneous thermal reactors, time behavior; reactor control. Multigroup theory. Heterogeneous systems. PREREQUISITES: PH 2810 or equivalent; differential equations.

PH 4952 Sensors, Signals, and Systems (4-2).
This course treats the physical phenomena and practical problems involved in sensor systems for electromagnetic signals. Topics included are: optical modulation, nonlinear optics, acousto-optics; atmospheric molecular absorption and aerosol scattering of radiation, from ultraviolet to infrared; characteristics and mechanisms of detectors for optical and infrared radiation, noise in detectors, cooling systems; image intensifiers, television and FLIR systems; detecting, tracking and homing systems; signal sources, target signatures and backgrounds; laser target designators, laser radars, the range equation. The laboratory will include experiments related to this material as well as to that of the preceding course, PH 3952. PREREQUISITES: PH 3952 and a course in electromagnetics.

PH 4953 Propagation Phenomena in Geophysical Environment (4-0).
This course emphasizes the properties of the geophysical media through which particles, energy or signals propagate. Topics include optical and IR transmission in the atmosphere, ionospheric physics, acoustic and electromagnetic waves in the sea, the satellite environment, geomagnetic phenomena and others of potential interest in defense applications. PREREQUISITE: PH 3360 or equivalent.

PH 4954 Particle Beam and High Energy Laser Weapon Physics (4-0).
This course is an indepth study into the beam weapon concepts. Topics covered are: relativistic electron beams; their equilibrium, propagation losses and stability; giant power accelerator concepts; target interaction; proton beams; neutral particle beams, their production and limitations; high power microwave beams, high energy laser beams, their production, atmospheric propagation and control and their interaction with targets. PREREQUISITES: PH 3360, PH 2151 or equivalent.

PH 4971-4972-4973 Quantum Mechanics I-II-III (3-0).
General principles of nonrelativistic quantum mechanics; stationary states. Addition of angular momenta; time-independent and time-dependent perturbation theory; scattering theory; identical particles and spin. General principles of relativistic quantum mechanics; properties and solutions of relativistic wave equations. PREREQUISITES: PH 3651, 4171.

PH 4991 Relativity and Cosmology (3-0).
Einstein's general theory of relativity. The three classical tests. The Schwarzchild singularity and black holes. Cosmological moddels and their relations with observations. Introduction to modern developments; gravitational waves, Dicke's theory, problems of quantum cosmology and superspace. PREREQUISITE: PH 4371.

PH 4998 Special Topics in Advanced Physics (1-0 to 4-0).
Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. PREREQUISITE: Consent of the Department Chairman. *It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.*

CHEMISTRY

Upper Division Courses

CH 2001 General Principles of Chemistry (3-2).
A study of the fundamental principles of chemistry governing the physical and chemical behavior of matter. Current theories of atomic structure and chemical bonding are particularly emphasized. Also studied are the states of matter and chemical equilibria. Special attention is given to the compounds of carbon. Elementary physical chemistry experiments are performed in the laboratory.

CH 2101 Inorganic Analysis (3-3).
A continuation of CH 2001. Computations involving acid-base, solubility, and complex ion equilibria. Principles of quantitative analysis. Descriptive inorganic chemistry. Laboratory work will consist of gravimetric and volumetric analysis. PREREQUISITE: CH 2001.

CH 2102 Inorganic Chemistry (3-3).
Redox reactions and the electrode potential. Introduction to reaction mechanism. Bonding in inorganic species. Acids and bases. Laboratory will make use of qualitative, semi-quantitative, and instrumental methods to study the principles further, especially as applied to the solution chemistry of the metals. PREREQUISITE: CH 2101 and CH 2402.

CH 2201 Chemical Instruments (3-3).
A course designed to familiarize the student with modern instrumental techniques of chemical analysis. Emphasis is given to the theoretical basic of the various kinds of measurements made in the laboratory and the principles involved in the design and construction of analytical instruments. Laboratory experiments will deal with representative analytical problems. PREREQUISITES: CH 2101 and CH 2403.

CH 2401 Chemical Thermodynamics (4-1).
The laws of thermodynamics and their applications to chemical systems. Use is made of the chemical potential in describing multicomponent systems and the conditions for thermodynamic equilibrium. PREREQUISITE: Differential equations.

CH 2402-2403 Physical Chemistry I-II (4-2) and (4-3).
A continuation of the subject matter of CH 2401 covering chemical equilibrium and kinetics, electrochemical cells, kinetic theory of gases and introductory atomic and molecular structure.

CH 2404 Thermodynamics and Physical Chemistry (4-2).
Brief review of general chemical principles. The laws of thermodynamics and their application to chemical systems. Thermochemistry, chemical equilibrium, electrochemistry, and chemical kinetics. The laboratory will reinforce the lecture material, especially through the use of chemical instruments. PREREQUISITE: Differential equations.

CH 2910 Interaction of Naval Operations and Environmental Pollution (4-0).
An interdisciplinary course which examines the impact of environmental pollution on Naval operations by examining current technical status, future plans for abatment, and the resultant limitations placed on

Naval facilities, especially ships. The course will consider air, water, nuclear, and noise pollution or the potential for pollution as appropriate. PREREQUISITES: Math through college algebra. Two quarters of physical science or biology within the last two years is desirable.

Upper Division or Graduate Courses

CH 3101 Advanced Inorganic Chemistry (3-3).
Coordination compounds and crystal field theory. Inorganic reaction mechanisms. The laboratory introduces the student to general methods for investigating chemical reaction. PREREQUISITES: CH 2101, CH 2403.

CH 3405 Molecular Dynamics (5-0).
Direct application of the Schroedinger wave equation to the hydrogen atom, angular momentum, matrix formulation of quantum mechanics, electron spin, the Pauli principle, interaction with electromagnetic radiation, development of group theory and application in quantum mechanics, and application of preceding framework to molecular hydridization, molecular orbital theory, ligand field theory, and vibrational spectra. PREREQUISITES: CH 2403, Matrix algebra.

CH 3998 Special Topics in Intermediate Chemistry (1-0 to 4-0).
Study in one of the fields of intermediate chemistry selected to meet special needs or interests of students. The course may be conducted as seminar or supervised reading and carries a letter grade. It may be repeated in different topics. PREREQUISITE: Consent of the Department Chairman. *It may also be taken on Pass/Fail basis if the student has requested so at the time of enrollment.*

Graduate Courses

CH 4406 Quantum Chemistry (3-0).
A study of molecular spectra and molecular electronic structure, emphasizing theory, interpretation, and prediction of spectra utilizing the quantum mechanical formulation. PREREQUISITE: CH 3405.

CH 4410 Chemical Kinetics (3-0).
Experimental methods and interpretations of data. Collison theory and activated-complex theory. Mechanisms of reactions. PREREQUISITES: CH 2403 and consent of Instructor.

CH 4505 Radiation Chemistry (3-0).
A study of the theory behind the chemical processes occurring when ionizing and electromagnetic radiation interact with matter. Includes electronic states of molecules, introduction to photochemistry, properties of gaseous ions and free radicals, chain reactions. PREREQUISITE: CH 2403 or the equivalent.

CH 4998 Special Topics in Advanced Chemistry (1-0 to 4-0).
Study in one of the fields of advanced chemistry or related applied areas selected to meet special needs or interest of students. The course may be conducted as seminar or supervised reading, carries a letter grade and may be repeated in different topics. PREREQUISITE: Consent of Department Chairman. *It may also be taken on Pass/Fail basis if the student has requested so at the time of enrollment.*

OTHER COURSES

The courses designated SE are a series of courses specifically designed for students in the Intelligence Curriculum (825).

Upper Division Courses

SE 2002 Electromagnetic Systems (4-0).
This course is designed to support the naval intelligence curriculum by providing an overview of the principles, concepts and trade-offs underlying systems whose operations requires the transmission and/or reception of electromagnetic energy. Topics treated in the course include: the electromagnetic spectrum and its usage, principles of electronic reconnaissance, antennas and their characteristics, factors affecting receiver sensitivity, transmission range, radar principles, the radar equation, optics fundamentals, infrared nomenclature, and principles and elements of photographic science.

SE 2279 Directed Studies in Science and Engineering (Credit open).
Independent study in science and engineering topics in which formal course work is not offered. PREREQUISITE: Permission of Department Chairman. *Graded on Pass/Fail basis only. (Graduate students register for SE 3279.)*

Upper Division or Graduate Courses

SE 3004 Weapons System Analysis (4-0).
This course is designed to support the Naval Intelligence curriculum. It treats the process of weapons system synthesis and analysis with special reference to surface to air and surface to surface missiles. Topics covered include: missile engagement analysis, guidance considerations for weapons system design, ECM considerations for defense and penetration, warhead and fusing consideration for weapons system design and examination of current U.S. and Soviet Systems. PREREQUISITES: SE 2002, EE 2003; SECRET clearance and U.S. Citizenship.

SE 3279 Directed Studies in Science and Engineering (Credit open).
(See SE 2279). *Graded on Pass/Fail basis only.*

Graduate Course

SE 4006 Technical Assessment and Intelligence Systems (4-0).
This course is designed to support the Naval Intelligence curriculum. It treats the role of intelligence in supporting the Naval planning and development process, the U.S. and Soviet Military R & D System, current technical trends affecting military capabilities, and current and projected capabilities of ocean surveillance and technical intelligence systems. PREREQUISITE: Advanced standing in the 825 curriculum.

Making turbulence measurements with the MTF equipment

DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

Discussion groups are an integral part of DRMEC educational activity

John Joseph Ekelund, Rear Admiral, U.S. Navy, Director; B.S., U.S. Naval Academy, 1949; M.S. in Systems Analysis, Univ. of Rochester, 1969.

John Edward Dawson, Professor; Executive Director (1966)*; B.A., The Principia College, 1953; M.P.A., Syracuse Univ., 1954; D.P.A., 1971.

James Sherman Blandin, Associate Professor; Assistant Director, Academic Programs (1974); B.A., Univ. of California at Santa Barbara, 1968; M.B.A., Univ. of Oregon, 1972; Ph.D., 1974.

Sherman Wesley Blandin, Jr., Professor; Assistant Director, Defense Activities (1968); B.S., U.S. Naval Academy, 1944; B.S., Georgia Institute of Technology, 1952; M.S., 1953; M.B.A., Univ. of Santa Clara, 1973; Ph.D., 1977.

William Alan Mauer, Professor, Assistant Director of Faculty Development and Research (1966); A.B., San Jose State College, 1955; M.S., Agricultural and Mechanical College of Texas, 1957; Ph.D., Duke Univ., 1960.

Alexander Wolfgang Rilling, Associate Professor; Assistant Director, International Activities (1974); B.S., Rensselaer Polytechnic Institute, 1951; M.S., Naval Postgraduate School, 1962; Ph.D., Univ. of Southern California, 1972.

Robert Moffat Allan, Jr., Professor (1971); B.A., Stanford Univ., 1941; M.S., Univ. of California at Los Angeles, 1942.

Robert Edward Boynton, Associate Professor (1970); B.A., Univ. of Minnesota, 1956; M.A., 1962; Ph.D., Stanford Univ., 1968.

William Ayers Campbell, Associate Professor (1970); B.S., Tuskegee Institute College, 1937; M.S.I.M., Univ. of Pittsburgh Graduate School, 1949.

Phillip Atkinson Costain, Lieutenant Colonel, U.S. Army; Instructor (1979); B.S., U.S. Military Academy, 1962; M.S. in Operations Research, Naval Postgraduate School, 1971.

Edwin John Doran, Associate Professor (1975); B.A., Univ. of Pennsylvania, 1955; M.S., Naval Postgraduate School, 1968; M.B.A., Univ. of Santa Clara, 1972; Ph.D., 1977.

Peter Carl Frederiksen, Associate Professor (1974); B.A., Golden Gate College, 1967; M.A., San Francisco State College, 1969; Ph.D., Washington State Univ., 1974.

Harley Leroy Gill, Assistant Professor (1980); B.A., Otterbein College, 1969; M.A., Ohio State Univ., 1971.

Peter David Ivory, Assistant Professor (1979); B.A., Univ. of California at Berkeley, 1971; M.A., Univ. of California at Santa Barbara, 1976; Ph.D., 1979.

Frank Wilbur Merritt, Jr., Lieutenant Commander, U.S. Navy; Instructor (1980); B.A., Howard Univ., 1961; M.S., Univ. of Wisconsin, 1974.

Harry Wilber Nieuwboer, Lieutenant Colonel, U.S. Army; Instructor (1980); B.S., U.S. Military Academy, 1962; M.S., Georgia Institute of Technology, 1972.

Norman Plotkin, Assistant Professor (1969); B.S., Univ. of California at Los Angeles, 1948; B.F.S., Georgetown Univ., 1950; M.S., Claremont Graduate School, 1966; Ph.D., 1969.

David Charles Roberts, Assistant Professor (1980); B.A., California State Univ. at Northridge, 1967; M.A., California State Univ. at Los Angeles, 1970; Ph.D., Univ. of Southern California, 1976.

William Richard Smith, Lieutenant Colonel, U.S. Marine Corps; Instructor (1979); B.A., Iona College, 1962; M.S., Naval Postgraduate School, 1971.

Robert von Pagenhardt, Professor (1967); A.B., Stanford Univ., 1948; M.S., 1954; Ph.D., 1970.

Leslie John Zambo, Major, U.S. Air Force; Assistant Professor (1980); B.S., St. Joseph's College, 1964; M.S., Air Force Institute of Technology, 1969; Ph.D., Univ. of Texas, 1981.

Emeritus Faculty

Frank Elmer Childs, Professor Emeritus (1965); B.A., Willamette Univ., 1934; M.B.A., Univ. of Southern California, 1936; Ph.D., Univ. of Minnesota, 1956.

Ivon William Ulrey, Professor Emeritus (1966); B.S., Ohio State Univ., 1931; M.B.A., New York Univ., 1937; Ph.D., Ohio State Univ., 1953.

Carlton Leroy Wood, Professor Emeritus (1966); B.A., Univ. of Washington, 1932; M.A., Columbia Univ., 1944; Ph.D., Heidelberg Univ., 1936.

**The year of joining the Postgraduate School faculty is indicated in parentheses.*

DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

Established in 1965 as the Navy Management Systems Center and redesignated to its present title in July 1974, the Defense Resources Management Education Center is a jointly staffed U.S. Department of Defense sponsored educational institution located as a tenant activity at the Naval Postgraduate School. It conducts educational programs in resources management, both in residence at Monterey and on-site, for military officers and civilian defense officials of the U.S. and cooperating foreign nations. The focus of all programs conducted by the Center is on the development of knowledge and improvement of understanding of the concepts, techniques and application of modern defense management systems, with specific emphasis on effective resource management. The mission, objectives and responsibilities of the Center are set forth in Department of Defense Directive 5010.35.

The Center currently offers the following resident courses within its facilities at the Naval Postgraduate School:

DEFENSE RESOURCES MANAGEMENT COURSE — four weeks in length; presented five times per year.

SENIOR DEFENSE RESOURCES MANAGEMENT COURSE — two weeks in length; presented periodically as scheduled (approximately once per year).

INTERNATIONAL DEFENSE MANAGEMENT COURSE — eleven weeks in length; presented twice a year.

SENIOR INTERNATIONAL DEFENSE MANAGEMENT COURSE — four weeks in length; presented once each year (normally in the month of June).

Descriptions of these courses are provided below; detailed information on current quota control agencies and procedures may be found in DOD Publication 5010.16-C (Defense Management Education and Training Catalog).

In addition to its regularly scheduled resident programs, the Center also provides:

MOBILE EDUCATION COURSES — normally two or three weeks in length, for U.S. military services and defense agencies, and for foreign governments upon specific request and approval.

COURSES FOR OTHER AGENCIES — programs of from two to four weeks duration, resident or on-site, for non-defense federal agencies and state and local governments, upon specific request and approval.

Faculty of the Center are members of the faculty of the Naval Postgraduate School on assignment to the Center.

Since 1966, over 12,700 officials, of whom over 4000 represented 61 foreign nations, have participated in programs conducted by the Center.

DEFENSE RESOURCES MANAGEMENT COURSE

The objective of this four-week course is to provide an appreciation of the concepts, principles, and methods of defense management as they concern planning, programming, budgeting, and related activities. The course covers force planning, Department of Defense programming, program budgeting, and their interrelationships with resource management systems. Emphasis is placed on the analytical aspects of management, stemming from the disciplines of management decision theory, economics, and quantitative analysis.

Participants are not expected to become experts or technicians in the various disciplines and subjects included in the curriculum. The objectives are to provide orientation on the overall functioning of the defense management process, insights as to what defense management requires in the way of inputs and analysis for decision-making, understanding of the principles, methods and techniques used, and awareness of the interfaces between management requirements of the Defense Department components and the Office of the Secretary of Defense. Course methodology includes lectures, small group discussions reinforced by illustrated case studies and problem sets, as well as selected daily reading assignments.

This course is primarily for U.S. officials, although limited numbers of foreign participants are normally also enrolled.

SENIOR DEFENSE RESOURCES MANAGEMENT COURSE

The two week program of profession-continuing education for U.S. flag and general officers, and civilian officials of equivalent grade (with limited foreign participation), is designed to improve understanding of the concepts, principles, methods and techniques drawn from the disciplines of management theory, economics and quantitative analysis. These ideas are integrated into a systematic framework for decision making. Applications include analysis and evaluation of defense systems, programs and policies and the allocation of scarce resources among programs. Course methodology includes lectures, small group discussions reinforced by illustrated case studies and problem sets as well selected daily reading assignments.

INTERNATIONAL DEFENSE MANAGEMENT COURSE

The course is designed for participants in the military grades of 0-4 (Major/Lieutenant Commander) through 0-6 (Colonel/Captain) and defense related civilians of equivalent rank. Enrollment is currently limited to a maximum of 50 participants. Broad national representation is desired for this course, i.e., participation of at least eight or ten nations enhances the value of the comparative management aspects of the curriculum.

The course is presented in English.

The course provides a series of lectures in three major areas: environmental factors; quantitative and economic analysis; and management systems in the context of strategy, implementation, and operations. The lectures are supplemented by small group discussions and workshops which concentrate on the lecture topics and associated readings, problems and cases. In the discussion groups, faculty members guide the interchange of ideas and are available to answer questions. Readings are assigned from within texts and supplemental material given to the participants to facilitate preparation for each lecture. Lecture outlines with additional suggested reading lists are provided. Occasional open seminar speakers are invited for special topics.

Early in the course, participants are requested to give brief presentations (by country) on their particular environmental situations, including such information as geographic factors, economic factors, social and cultural considerations, governmental and defense organizations, and unique management situations and/or problems. Throughout the course, the participants are encouraged to present and discuss information with respect to the defense management systems of their countries, and to examine how the management concepts and techniques discussed by both the Center faculty and the participants from other countries may be applied in their own situations. Comparative study by means of interaction among participants is considered to be an extremely valuable characteristic of the course.

During the course, the Center conducts field trips to selected military and commercial installations in the central California area. These trips provide an opportunity for the participants to receive special briefings on management techniques and problems, and to observe actual practices at the operating level.

In the second half of the course the general concepts of defense management are elaborated in detail during the examination of actual systems in financial, material and human recources management. At the end of the course a general review integrates the formal course material, special topics, and field trip experiences.

SENIOR INTERNATIONAL DEFENSE MANAGEMENT COURSE

Enrollment is restricted to military flag and general officers (grades 0-7 and above) and defense-related civilians of equivalent rank, except that for countries where the 0-6 grade is comparable to flag/general rank such officials may be enrolled on a waiver basis. Participation in this course is normally from 40 to 50 senior officials from as many as 22 countries.

The course is presented in English.

The lecture, small discussion group, environmental seminar, case study and problem format and content described above for IDMC also applies, but compressed in time. Two or three guest speakers, including at least one high level official in a policy position in a foreign government, are invited to address the class and a short field trip is conducted.

TENTATIVE FY 82 SCHEDULE OF RESIDENT COURSES

SDRMC (2 weeks)	30 Nov - 11 Dec 81
DRMC (4 weeks)	4 Jan - 29 Jan 82
IDMC (11 weeks)	1 Feb - 23 Apr 82
DRMC (4 weeks)	26 Apr - 14 May 82
DRMC (4 weeks)	17 May - 11 Jun 82
SIDMC (4 weeks)	14 Jun - 9 Jul 82
DRMC (4 weeks)	12 Jul - 6 Aug 82
DRMC (4 weeks)	9 Aug - 3 Sep 82
IDMC (11 weeks)	13 Sep - 25 Nov 82

NOTE: The above dates are tentative and subject to change.

DISTINGUISHED ALUMNI

Among those U.S. officers who have completed a curricular program at the Naval Postgraduate School, the following officers (USN or USMC unless otherwise indicated) have attained flag rank on the active list:

Admiral Walter F. Boone
Admiral Arleigh A. Burke
Admiral Cato D. Glover, Jr.
Admiral Charles D. Griffin
Admiral Ephraim P. Holmes
Admiral Frederick H. Michaelis
Admiral Alfred M. Pride
Admiral Hyman G. Rickover*
Admiral James S. Russell
Admiral Ulysses S. G. Sharp, Jr.
Admiral Alfred G. Ward
Admiral James D. Watkins*
Admiral John M. Will
Vice Admiral Robert E. Adamson, Jr.
Vice Admiral Frederick L. Ashworth
Lieutenant General George C. Axtell, Jr.
Vice Admiral Lee Baggett, Jr.*
Vice Admiral Harold D. Baker
Vice Admiral George F. Beardsley
Vice Admiral Fred G. Bennett
Vice Admiral Charles T. Booth, II
Vice Admiral Harold G. Bowen, Jr.
Vice Admiral Jon L. Boyes
Vice Admiral Edward S. Briggs*
Vice Admiral Carleton F. Bryant
Vice Admiral William M. Callaghan
Vice Admiral Ralph W. Christie
Vice Admiral John B. Colwell
Vice Admiral Thomas F. Connolly
Vice Admiral Glenn B. Davis
Vice Admiral Vincent P. Depoix
Vice Admiral Harold T. Deutermann
Vice Admiral Glynn R. Donaho
Vice Admiral Clarence E. Ekstrom
Vice Admiral Albert J. Fay
Vice Admiral William E. Gentner, Jr.
Vice Admiral Arthur R. Gralla
Vice Admiral Truman J. Hedding
Vice Admiral "M" Staser Holcomb*
Vice Admiral Edwin B. Hooper
Vice Admiral George F. Hussey, Jr.
Vice Admiral Thomas B. Inglis
Vice Admiral Andrew M. Jackson, Jr.
Vice Admiral Robert T.S. Keith
Vice Admiral Ingolf N. Kiland
Vice Admiral Jerome H. King, Jr.
Vice Admiral Harold O. Larson
Vice Admiral Kent L. Lee
Vice Admiral Ruthven E. Libby
Vice Admiral Vernon L. Lowrance
Vice Admiral William J. Marshall
Vice Admiral Kleber S. Masterson
Vice Admiral Ralph E. McShane
Vice Admiral Charles L. Melson
Lieutenant General John H. Miller*
Vice Admiral Marion E. Murphy
Vice Admiral Lloyd M. Mustin
Vice Admiral Gordon R. Nagler*
Vice Admiral Frank O'Beirne
Vice Admiral Howard E. Orem
Vice Admiral Edward N. Parker
Vice Admiral Raymond E. Peet
Vice Admiral Forrest S. Petersen
Vice Admiral Thomas C. Ragan
Vice Admiral Lawson P. Ramage
Vice Admiral William L. Rees
Vice Admiral Robert H. Rice
Vice Admiral Rufus E. Rose
Vice Admiral William H. Rowden*
Vice Admiral Theodore D. Ruddock, Jr.
Vice Admiral Lorenzo S. Sabin
Vice Admiral Harry Sanders
Vice Admiral Walter G. Schindler
Vice Admiral William A. Schoech
Vice Admiral Harry E. Sears
Vice Admiral Ernest R. Seymour*
Vice Admiral Wallace B. Short
Lieutenant General Philip D. Shutler
Vice Admiral William R. Smedberg, III
Vice Admiral John V. Smith
Vice Admiral Roland N. Smoot
Vice Admiral Selden B. Spangler
Vice Admiral Thomas M. Stokes
Vice Admiral John Sylvester
Vice Admiral George C. Towner
Vice Admiral Robert L. Townsend
Vice Admiral Thomas J. Walker, III
Vice Admiral Edward C. Waller, III*
Vice Admiral Charles Wellborn, Jr.
Vice Admiral Thomas R. Weschler
Vice Admiral Ralph Weymouth
Vice Admiral Ralph E. Wilson
Rear Admiral William C. Abhau
Rear Admiral Charles Adair
Rear Admiral Herbert S. Ainsworth

Rear Admiral Frank Akers
Rear Admiral David M. Altwegg*
Rear Admiral Charles C. Anderson
Rear Admiral Herbert H. Anderson
Rear Admiral Roy G. Anderson
Rear Admiral William L. Anderson
Rear Admiral Burton H. Andrews
Rear Admiral Henry J. Armstrong
Rear Admiral Henry D. Arnold*
Rear Admiral James W. Austin*
Rear Admiral Robert C. Austin*
Rear Admiral Richard C. Avrit*
Rear Admiral William B. Bailey
Rear Admiral Fred E. Bakutis
Rear Admiral Nathaniel C. Barker
Rear Admiral Edwin Barrineau*
Rear Admiral Robert L. Baughan, Jr.
Rear Admiral Fred H. Baughman*
Rear Admiral John D. Beecher*
Rear Admiral John K. Beling
Rear Admiral David B. Bell
Rear Admiral Allen A. Bergner
Rear Admiral Philip A. Beshany
Rear Admiral Abel T. Bidwell
Rear Admiral Karl J. Bierderman
Rear Admiral Horace V. Bird
Rear Admiral Ralph G. Bird*
Rear Admiral Worthington S. Bitler
Brigadier General Herbert J. Blaha
Rear Admiral Wayne D. Bodensteiner*
Rear Admiral Calvin M. Bolster
Rear Admiral Selman S. Bowling
Rear Admiral Frank A. Braisted
Rear Admiral Boynton L. Braun
Brigadier General George R. Brier
Rear Admiral Harold M. Briggs
Rear Admiral William A. Brockett
Rear Admiral Clarence Broussard
Rear Admiral Bert F. Brown
Rear Admiral Henry C. Bruton
Rear Admiral William C. Bryson
Rear Admiral Charles A. Buchanan
Rear Admiral Raymond W. Burk
Rear Admiral James B. Busey*
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Rear Admiral Joseph W. Callahan
Rear Admiral Lucien Capone, Jr.
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Rear Admiral Kenan C. Childers, Jr.
Rear Admiral William P. Chilton
Rear Admiral Ernest E. Christensen
Rear Admiral Thomas J. Christman
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Rear Admiral Glenwood Clark, Jr.*
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Rear Admiral James A. Dare
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Rear Admiral Oscar H. Dodson
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Rear Admiral Crawford A. Easterling*
Rear Admiral Scott W. Ebert*

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Rear Admiral Edward H. Eckelmeyer, Jr.
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Rear Admiral Donald McGregor
Rear Admiral Fran McKee*
Rear Admiral Logan McKee
Rear Admiral James E. McKenna*
Rear Admiral Philip S. McManus
Rear Admiral Robert W. McNitt
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Rear Admiral John L. Melgaard
Rear Admiral Robert E. Melling
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Rear Admiral Richard A. Miller*
Rear Admiral Rupert S. Miller
Rear Admiral Robert G. Mills
Rear Admiral Clinton A. Misson
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Rear Admiral Chauncey Moore
Rear Admiral Michael U. Moore
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Rear Admiral Grover M. Yowell
Rear Admiral William M. Zobel*

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Rear Admiral Donald L. Conner*
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Rear Admiral Donald E. Wilson*
Brigadier General John J. Yeosock, USA*

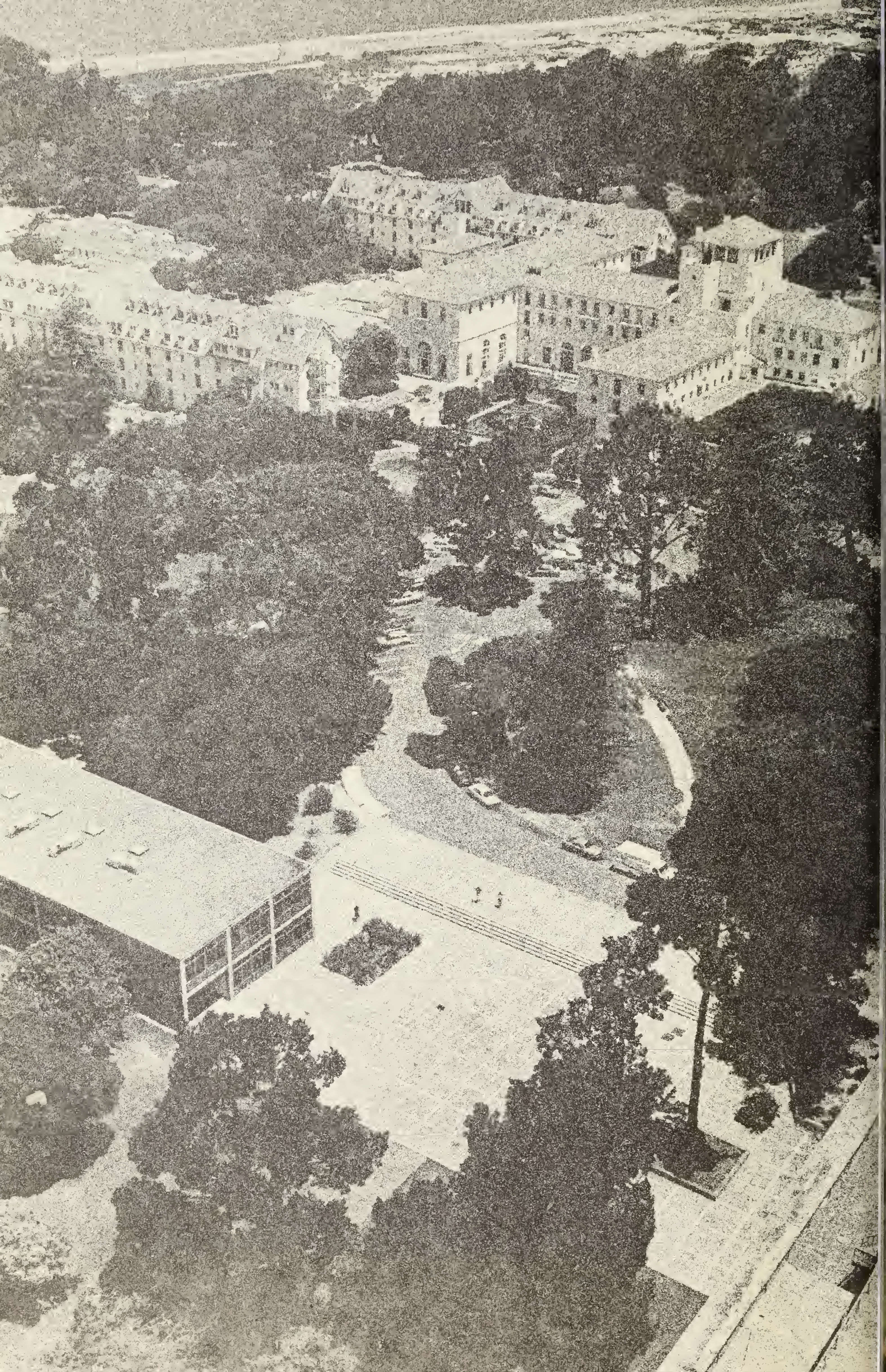
** The asterisk indicates those on active list as of 1 April 1981.*

Graduating Class, June 1981

POSTGRADUATE SCHOOL STATISTICS GRADUATES BY YEARS

POSTGRADUATE SCHOOL STATISTICS
GRADUATES BY YEARS

	1946-1950	1951-1955	1956-1960	1961-1965	1966-1970	1971-1975	1976-1978	1979	1980	Total
Bachelor of Arts	....	....	....	180	389	349	1	....	....	919
B.S. in Aeronautical Engineering	73	212	212	181	61	15	....	....	....	754
B.S. in Chemistry	....	....	3	3	4	9	....	....	....	19
B.S. in Engineering Acoustics	....	....	....	....	....	3	5	....	....	8
B.S. in Electrical Engineering	156	292	232	520	308	186	48	33	29	1,804
B.S. in Engineering Science	....	....	....	....	141	135	....	....	....	276
B.S. in Environmental Science	....	....	....	12	....	....	....	....	....	12
B.S. in Management	....	....	....	53	1	....	....	....	....	54
B.S. in Mechanical Engineering	43	116	52	82	53	26	11	8	4	395
B.S. in Meteorology	16	104	77	108	49	29	....	....	....	383
B.S. in Operations Research	....	....	....	....	49	63	13	3	3	131
B.S. in Physics	....	15	36	75	35	19	4	....	....	184
B.S. in Systems Technology	....	....	....	....	....	....	7	....	....	7
Bachelor of Science	....	36	94	583	259	210	11	2	7	1,222
Total Baccalaureate Degrees	288	795	706	1,797	1,349	1,044	100	46	43	6,168
M.A. in National Security Affairs	....	....	....	....	....	23	131	77	71	302
M.S. in Aeronautical Engineering	....	....	....	40	115	224	113	18	19	529
M.S. in Applied Science	....	....	....	....	....	....	36	3	2	41
M.S. in Chemistry	....	....	16	5	32	16	....	....	....	69
M.S. in Computer Science	....	....	....	....	34	139	96	33	33	335
M.S. in Computer Systems Management	....	....	....	22	247	294	108	48	51	770
M.S. in Electrical Engineering	75	154	124	190	318	345	163	63	85	1,517
M.S. in Engineering Acoustics	....	....	....	....	13	37	24	6	4	84
M.S. in Engineering Science	....	....	....	....	....	....	....	9	18	27
M.S. in Management	....	....	....	406	633	964	401	154	141	2,699
M.S. in Material Science	....	....	....	5	9	....	....	....	....	14
M.S. in Mechanical Engineering	20	36	48	49	99	132	75	24	34	517
M.S. in Meteorology	23	19	40	53	53	126	24	2	6	346
M.S. in Oceanography	....	....	....	....	119	179	40	13	23	374
M.S. in Meteorology and Oceanography	....	....	....	....	....	....	27	6	10	43
M.S. in Operations Research	....	....	....	63	305	549	168	60	65	1,210
M.S. in Physics	....	25	104	135	124	102	45	12	16	563
M.S. in Systems Technology	....	....	....	....	....	19	79	34	67	199
M.S. in Telecommunications Systems Management	....	....	....	....	....	....	10	18	9	37
M.S. in Applied Mathematics	....	....	....	....	....	....	2	2	1	5
Master of Science	....	17	65	102	56	25	5	....	....	270
Total Master's Degrees	118	251	397	1,070	2,157	3,174	1,547	582	655	9,951
Aeronautical Engineer	....	....	....	4	33	45	8	2	5	97
Electrical Engineer	....	....	....	....	40	64	24	8	10	146
Mechanical Engineer	....	....	....	....	6	25	22	4	7	64
Doctor of Philosophy	....	....	1	14	25	38	14	5	4	101
Doctor of Engineering	....	....	....	....	....	....	1	....	2	3
Total Degrees	406	1,046	1,104	2,885	3,610	4,390	1,716	647	726	16,530



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